Biological Services Program

DEVELOPMENT OF FISHES OF THE MID-ATLANTIC BIGHT

AN ATLAS OF EGG, LARVAL AND JUVENILE STAGES

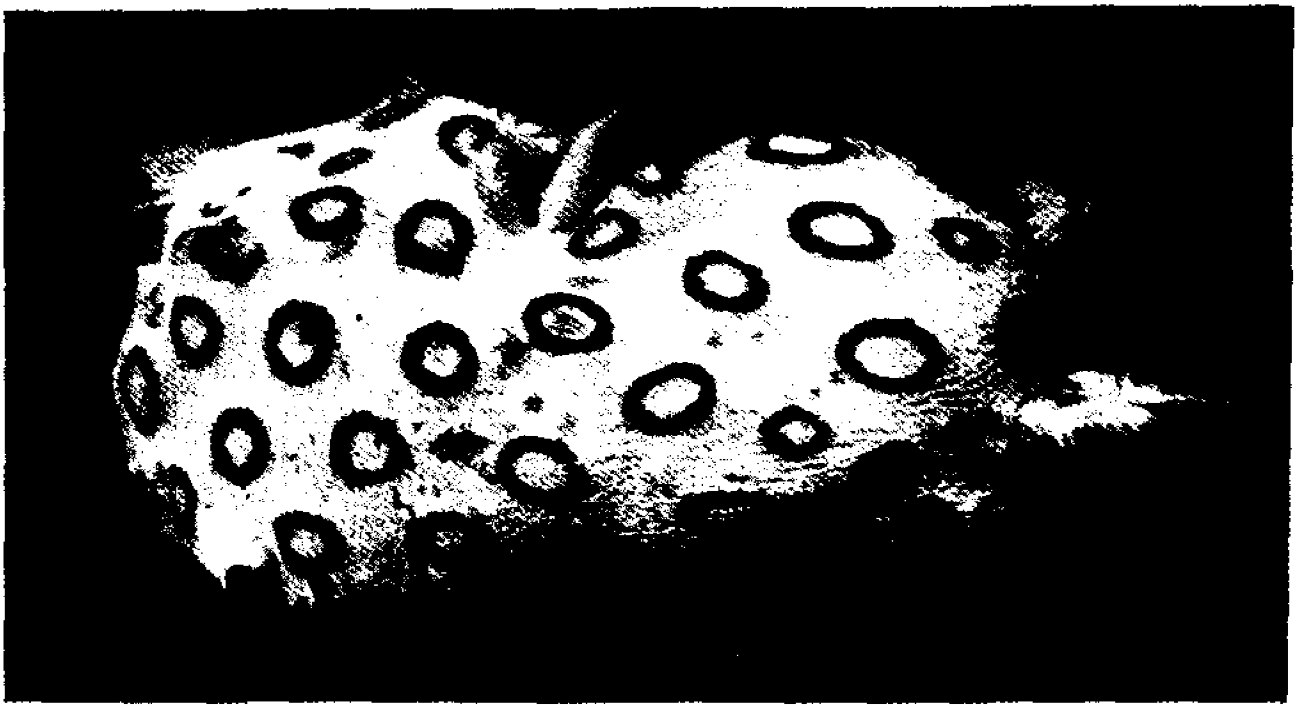
VOLUME

VI

STROMATEIDAE THROUGH OGCOCEPHALIDAE

Fish and Wildlife Service

U.S. Department of the Interior



Frontispiece: Prejuvenile of *Chilomycterus* sp., dorsal view. (*Böhlke, J. E., and C. C. G. Chaplin, 1968:694. © Academy of Natural Sciences of Philadelphia. Used with permission of publisher and authors.*)

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DEVELOPMENT OF FISHES OF THE MID-ATLANTIC BIGHT

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STROMATEIDAE THROUGH OGCOCEPHALIDAE

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Performed for
Power Plant Project
Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior

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DISCLAIMER

The opinions, findings, conclusions, or recommendations expressed in this product are those of the authors and do not necessarily reflect the views of the Office of Biological Services, Fish and Wildlife Service, U.S. Department of the Interior.

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FOREWORD

The demand for electric energy often creates conflicts with the desire to preserve and protect the Nation's fish and wildlife resources. This is particularly true when the use of water for power plants is considered. Power plants require large volumes of water from rivers, lakes, reservoirs, and estuaries. Withdrawal of water for cooling purposes causes the loss of fish eggs, larvae, and juveniles through impingement or entrainment. The discharge of water causes thermal and chemical pollution, and can cause alteration of stream flow patterns and the disruption of the thermal and dissolved oxygen stratification in those water bodies.

The biological consequences of water use by power plants depend upon the species of organisms involved, the mechanical and physiological stresses on the organisms, and the ecological role of the organisms. To assess the impacts of power plants and other habitat modifications on fish populations, it is necessary to identify fish eggs, larvae, and juveniles of different species. However, up to now, descriptions of the developmental stages of fishes have been scattered throughout a large number of sources.

The *Development of Fishes of the Mid-Atlantic Bight* is a reference which compiles descriptions of the egg, larval, and juvenile stages of over 300 fish species, and includes dichotomous keys useful for identifying species. Descriptions of spawning migrations and life habits of adult fishes, their geographic range and distribution, and movements of fish at all life stages are also included.

With this kind of baseline taxonomic information, biologists will be able to assess the management implications of power plant siting and other habitat modifications on aquatic populations and provide information to decision makers. We believe these books are a major step in providing the type of information necessary to incorporate environmental considerations into resource development decisions.

Lynn A. Greenwalt

Director, U.S. Fish and Wildlife Service

The Biological Services Program was established within the U.S. Fish and Wildlife Service to supply scientific information and methodologies on key environmental issues which impact fish and wildlife resources and their supporting ecosystems. The mission of the Program is as follows:

1. To strengthen the Fish and Wildlife Service in its role as a primary source of information on national fish and wildlife resources, particularly in respect to environmental impact assessment.
2. To gather, analyze, and present information that will aid decision makers in the identification and resolution of problems associated with major land and water use changes.
3. To provide better ecological information and evaluation for Department of the Interior development programs, such as those relating to energy development.

Information developed by the Biological Services Program is intended for use in the planning and decision making process to prevent or minimize the impact of development on fish and wildlife. Biological Services research activities and technical assistance services are based on an analysis of the issues, the decision makers involved and their information needs, and an evaluation of the state of the art to identify information gaps and determine priorities. This is a strategy to assure that the products produced and disseminated will be timely and useful.

Biological Services projects have been initiated in the following areas:

- Coal extraction and conversion
- Power plants
- Geothermal, mineral, and oil shale development
- Water resource analysis, including stream alterations and western water allocation
- Coastal ecosystems and Outer Continental Shelf development
- Systems and inventory, including National Wetlands Inventory, habitat classification and analysis, and information transfer.

The Program consists of the Office of Biological Services in Washington, D.C., which is responsible for overall planning and management; National Teams which provide the Program's central scientific and technical expertise and who arrange for contracting Biological Services studies with States, universities, consulting firms, and others; regional staff who provide a link to problems at the operating level; and staff at certain Fish and Wildlife Service research facilities who conduct in-house research studies.

CONTENTS

GENERAL INTRODUCTION

As noted by Mansueti and Hardy (1967) in the first edition of Volume I of this series, the early developmental stages of most fishes are either poorly known or completely unknown. Despite the fundamental importance of this knowledge to many aspects of fishery biology and ichthyology, this situation still persists.

OBJECTIVES

The primary purpose of this series is to synthesize the world literature on fishes occurring in the Mid-Atlantic Bight of the United States. The successful accomplishment of this goal serves a number of useful functions, among which are greater ease in identifying young fishes and fish eggs, the systematization of information gaps, and the stimulation of studies in areas where such gaps have been clearly demonstrated. Although some original data have been included in this series, time constraints have kept this to a minimum, primary efforts having been directed toward a comprehensive review of existing literature.

FORMAT

The geographical area considered extends from the northern boundary of New Jersey to the southern boundary of Virginia from tidal freshwater out to the 100 fathom contour (see fig. 1).

Data have been presented on 321 species. Mansueti and Hardy (1967) arranged the species in Volume I in the sequence used by the American Fisheries Society (1960). Although disagreements exist with this arrangement as a phylogenetic sequence it is used here to order the species and families in this series so that the revised Volume I will remain intact. In some cases recent systematic revisions have demanded realignment at familial levels or the updating of generic and specific names.

The series is presented in six volumes as follows: Volume I, Acipenseridae through Ictaluridae, 50 species; Volume II, Anguillidae through Syngnathidae, 48 species; Volume III, Aphredoderidae through Rachycentridae, 52 species; Volume IV, Carangidae through Ephippidae, 52 species; Volume V, Chaetodontidae through Ophidiidae, 52 species; and Volume VI, Stromateidae through Ogcocephalidae, 67 species.

Species accounts are arranged alphabetically within family groupings. Each species account is divided into the following major divisions:

ADULTS—meristics, morphometrics and general description.

DISTRIBUTION AND ECOLOGY—range, habitat and movements of adults, larvae, and juveniles.

SPAWNING—description of season, location, conditions of spawning, and fecundity.

EGGS—description of ripe ovarian, unfertilized or fertilized eggs.

EGG DEVELOPMENT—developmental sequences, physical limiting factors and incubation times.

YOLK-SAC LARVAE—size range, morphology, development and pigmentation.

LARVAE—size range, morphology, development and pigmentation.

PREJUVENILES (not recognized in all volumes)—size range, morphology, development and pigmentation.

JUVENILES—size range, morphology, development and pigmentation.

GROWTH (not given in all volumes)—average and/or representative growth rates, especially preadult growth.

AGE AND SIZE AT MATURITY—average age and size at maturity plus variation if these data are available.

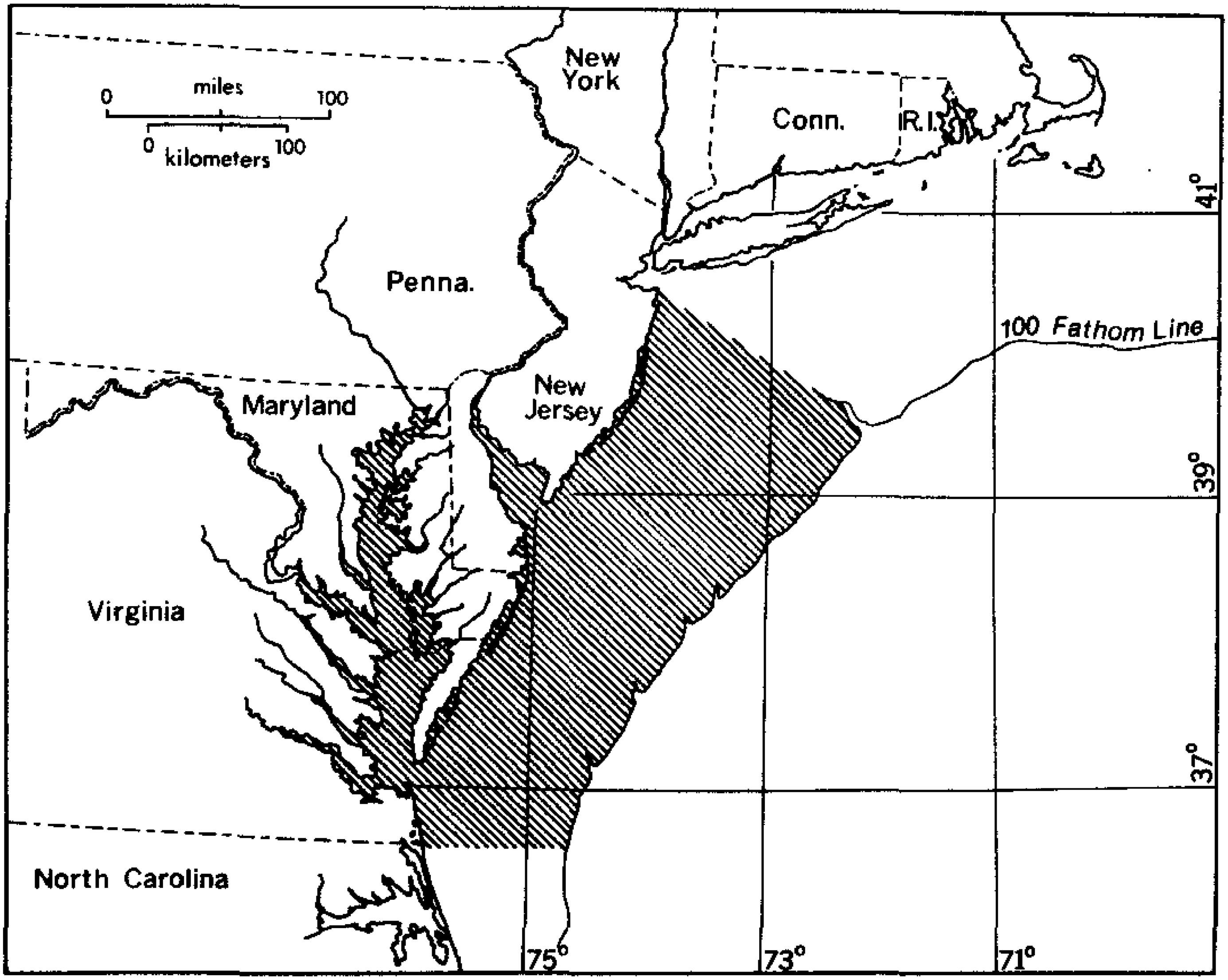

Fig. 1. Map of the Chesapeake Bay and adjacent Mid-Atlantic Bight. Hatching indicates the area considered in this series.

Literature cited—abbreviated citations to literature consulted for that account. Complete citations in Bibliography.

Superscript numbers in each species account refer to the abbreviated citations given at the end of each account. Complete citations may be found in the bibliography at the end of each volume. In prefaces, introductions, family accounts and figure legends, citations are given by author and date, rather than superscript. Throughout, parenthetical initials follow original unpublished information provided by the person whose initials are given (see preface for full name and address). Each volume has its own bibliography and index. No cumulative bibliography or index has been attempted.

Illustrations are of mixed quality and utility. For the most part they are simply reprinted from the literature. In some cases, however, previously published figures have been redrawn, and a number of original illustrations are included. Figure legends cite the artist or delineator. Redrawings are usually of figures which are unique in that they provide the only illustrations of particular features or stages and will not reproduce well or are confusing or inaccurate in detail. Attempts have been made to exclude drawings of misidentified specimens; however, error in judgement is possible. Where available, multiple illustrations of the same stage are included if they show geographic variation or if the authors were unable to determine which illustration provided the most accurate representation. In addition, a number of drawings which have been published in rare or generally unavailable sources have been included primarily for their historic value.

TERMINOLOGY

For the most part, terminology and methods of measuring and counting are those of Hubbs and Lagler (1958); however, these terms are specifically for adult forms and must be modified or replaced by different ones for early developmental stages.

For illustrations of typical developmental stages and larval anatomy see fig. 2.

Definitions and terms for developmental stages vary considerably depending on the investigator and the species worked on. The following terminology has been standardized:

YOLK-SAC LARVA—stage between hatching and absorption of yolk;

LARVA—stage between absorption of yolk and acquisition of minimum adult fin ray complement;

PREJUVENILE—stage between acquisition of minimum adult fin ray complement and assumption of adult body form; used only where strikingly different from juvenile (cf. Hubbs, 1958; *Tholichthys* stage of butterflyfishes, querimana stage of mullets, etc.);

JUVENILE—stage between acquisition of minimum adult fin ray complement and sexual maturity or between prejuvenile stage and adult;

ADULT—sexually mature.

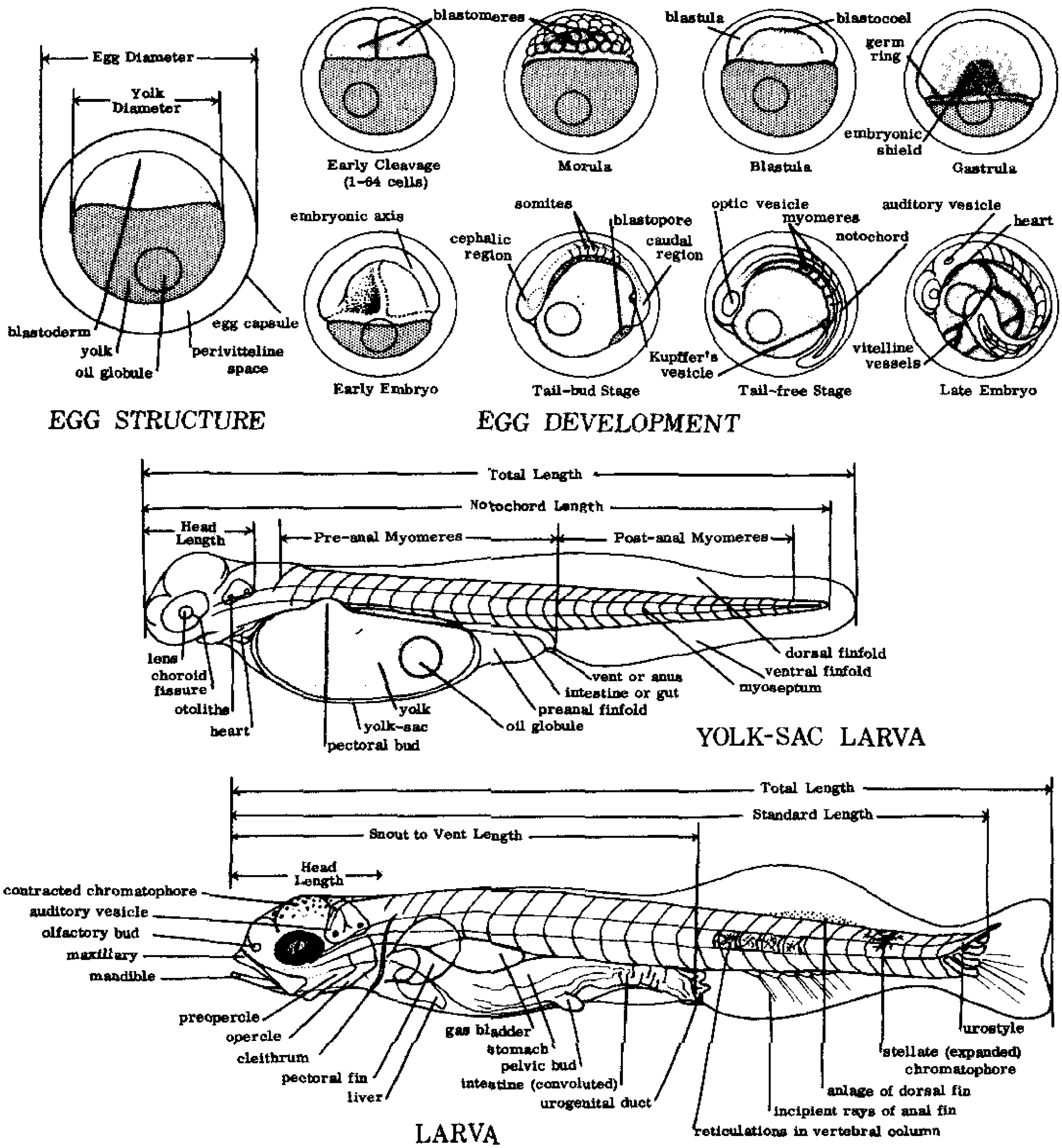

Fig. 2. Diagrammatic representation of morphology and development of egg and larval stages of a typical teleost.

GLOSSARY

A. Abbreviation for anal fin.

abbreviate heterocercal. Tail in which the vertebral axis is prominently flexed upward, only partly invading upper lobe of caudal fin; fin fairly symmetrical externally.

adherent. Attached or joined together, at least at one point.

adhesive egg. An egg which adheres on contact to substrate material or other eggs; adhesiveness of entire egg capsule may or may not persist after attachment.

adipose fin. A fleshy rayless median dorsal structure, located behind the true dorsal fin.

adnate. Congenitally united; conjoined.

adult. Sexually mature as indicated by production of gametes.

anadromous. Fishes which ascend rivers from the sea to spawn.

anal. Pertaining to the anus or vent.

anal fin. Unpaired median fin immediately behind anus or vent.

anal fin origin. Anteriormost point at which the anal fin attaches to the body.

anlage. Rudimentary form of an anatomical structure; primordium.

anus. External orifice of the intestine; vent.

auditory vesicle. Sensory anlage from which the ear develops; clearly visible during early development.

axillary process. Enlarged accessory scale attached to the upper or anterior base of pectoral or pelvic fins.

BL. Abbreviation for body length.

barbel. Tactile process arising from the head of various fishes.

blastocoel. Cavity of the blastula; segmentation cavity.

blastoderm. *Sensu strictu*, early embryonic tissue composed of blastomeres; more generally, embryonic tissue prior to formation of embryonic axis.

blastodisc. Embryo-forming area of egg prior to cleavage.

blastomeres. Individual cells formed during cleavage.

blastopore. Opening formed by and bordered by the germ ring as it extends over the yolk.

blastula. Stage in embryonic development which represents the final product of cleavage stages, characterized by formation of the blastocoel.

body length. A specialized method of measuring, generally applied only to billfishes, and defined by Rivas (1956a) as the distance from the tip of the mandible (with jaws closed) to the middle point on the posterior margin of the middle caudal rays.

branched ray. Soft ray with two or more branches distally.

branchial arches. Bony or cartilaginous structures, supporting the gills, filaments and rakers.

branchiostegals. Struts of bone inserting on the hyoid arch and supporting, in a fanwise fashion, the branchiostegal membrane; branchiostegal rays.

buoyant egg. An egg which floats free within the water column; pelagic.

C. Abbreviation for caudal fin.

caeca. Finger-like outpouchings at boundary of stomach and intestine.

catadromous. Fishes which go to sea from rivers to spawn.

caudal fin. Tail fin.

caudal peduncle. Area lying between posterior end of anal fin base and base of caudal fin.

cheek. Lateral surface of head between eye and opercle, usually excluding preopercle.

chorion. Outer covering of egg; egg capsule.

choroid fissure. Line of juncture of invaginating borders of optic cup; apparent in young fish as a trough-like area below lens.

chromatophores. Pigment-bearing cells; frequently capable of expansions and contractions which change their size, shape, and color.

cirrus. Generally small, dermal, flap-like or tentacle-like process on the head or body.

cleavage stages. Initial stages in embryonic development where divisions of blastomeres are clearly marked; usually include 1st through 6th cleavages (2–64 cells).

cleithrum. Prominent bone of pectoral girdle, clearly visible in many fish larvae.

ctenoid scale. Scales with comb-like margin; bearing cteni.

cycloid scale. Scales with evenly curved free border, without cteni.

D. Abbreviation for dorsal fin.

demersal egg. An egg which remains on the bottom, either free or attached to substrate.

dorsal fins. Median, longitudinal, vertical fins located on the back.

dorsal fin origin. Point where first dorsal ray or spine attaches to body.

early embryo. Stage in embryonic development characterized by formation of embryonic axis.

egg capsule. Outermost encapsulating structure of the egg, consisting of one or more membranes; the protective shell.

egg diameter. In nearly spherical eggs, greatest diameter; in elliptical eggs given as two measurements, the greatest diameter or major axis and the least diameter or minor axis.

emarginate. Notched but not definitely forked, as in the shallowly notched caudal fin of some fishes.

embryonic axis. Primitive differentiation of the embryo; an elongate thickening of blastodermal tissue.

embryonic shield. Thickened shield-like area of the blastoderm at caudal edge of the germ ring.

erythrophores. Red or orange chromatophores.

esophagus. Alimentary tract between pharynx and stomach.

falcate. Deeply concave as a fin with middle rays much shorter than anterior and posterior rays.

finfold. Median fold of integument which extends along body of developing fishes and from which median fins arise.

FL. Abbreviation for fork length.

fork length. Distance measured from the anteriormost point of the head to the end of the central caudal rays.

ganoid scales. Diamond- or rhombic-shaped scales consisting of bone covered with enamel.

gas bladder. Membranous, gas-filled organ located between the kidneys and alimentary canal in teleosts; air bladder or swim bladder.

gastrula. Stage in embryonic development between blastula and embryonic axis.

germ ring. The thickened rim of the blastoderm evident during late blastula and gastrula stages.

germinal disc. The blastodisc.

gill arches. See branchial arches.

gill rakers. Variously-shaped bony projections on anterior edge of the gill arches.

granular yolk. Yolk consisting of discrete units of finely to coarsely granular material.

guanophores. White chromatophores; characterized by presence of iridescent crystals of guanine.

gular fold. Transverse membrane across throat.

gular plate. Ventral bony plate between anterior third of lower jaws, as in *Amia calva.*

heterocercal. Tail in which the vertebral axis is flexed upward and extends nearly to tip of upper lobe of caudal fin; fin typically asymmetrical externally, upper lobe much longer than lower.

HL. Abbreviation for head length.

head length. Distance from anteriormost tip of head to posteriormost part of opercular membrane, excluding spine; prior to development of operculum, measured to posterior end of auditory vesicle.

holoblastic. Type of cleavage in which the entire egg, including the yolk, undergoes division.

homocercal. Tail in which the vertebral axis terminates in a penultimate vertebra followed by a urostyle (the fusion product of several vertebral elements); fin perfectly symmetrical externally.

hypochord. A transitional rod of cells which develops under the notochord in the trunk region of some embryos.

hypurals. Expanded, fused, haemal spines of last few vertebrae which support caudal fin.

incubation period. Time from fertilization of egg to hatching.

interorbital. Space between eyes over top of head.

iridocytes. Crystals of guanine having reflective and iridescent qualities.

isocercal. Tail in which vertebral axis terminates in median line of fin, as in Gadiformes.

isthmus. The narrow area of flesh in the jugular region between gill openings.

jugular. Pertaining to the throat.

juvenile. Young fish after attainment of minimum adult fin ray counts and before sexual maturation.

keeled. With a ridge or ridges.

Kupffer's vesicle. A small, vesicular, ventro-caudal pocketing which forms as blastopore narrows.

larva. Young fish between time of hatching and attainment of minimum adult fin ray counts.

late embryo. Stage prior to hatching in which the embryo has developed external characteristics of its hatching stage.

lateral line. Series of sensory pores and/or tubes extending backward from head along sides.

lateral line scales. Pored or notched scales associated with the lateral line.

mandible. Lower jaw, comprised of three bones: dentary, angular and articular.

maxillary. The dorsalmost of the two bones in the upper jaw.

Meckel's cartilage. Embryonic cartilaginous axis of the lower jaw in bony fishes.

melanophores. Black chromatophores.

mental. Pertaining to the chin.

meroblastic. Type of cleavage in which only the blastodisc undergoes division.

micropyle. Opening in egg capsule through which spermatozoa enter.

morula. Stage in development of egg in which blastomeres form a mulberry-like cluster.

myomeres. Serial muscle bundles of the body.

myoseptum. Connective tissue partitions separating myomeres.

nape. Area immediately posterior to occipital region.

nasal. Pertaining to region of the nostrils, or to the specific bone in that region.

NL. Abbreviation of notochord length.

notochord. Longitudinal supporting axis of body which is eventually replaced by the vertebral column in teleostean fishes.

notochord length. Straight-line distance from anteriormost part of head to posterior tip of notochord; used prior to and during notochord flexion.

occipital region. Area on dorsal surface of head, beginning above or immediately behind eyes and extending backwards to end of head.

oil globule(s). Discrete sphere(s) of fatty material within the yolk.

olfactory buds. Incipient olfactory organs.

optic vesicles. Embryonic vesicular structures which give rise to the eyes.

otoliths. Small, calcareous, secreted bodies within the inner ear.

P. Abbreviation for pectoral fin.

palatine teeth. Teeth on the paired palatine bones in the roof of the mouth of some fishes.

pectoral bud. Swelling at site of future pectoral fin; anlage of pectoral fin.

pectoral fins. Paired fins behind head, articulating with pectoral girdle.

pelagic. Floating free in water column; not necessarily near the surface.

pelvic bud. Swelling at site of future pelvic (ventral) fins; anlage of pelvic fin.

pelvic fins. Paired fins articulating with pelvic girdle; ventral fins.

periblast. A layer of tissue between the yolk and cells of blastoderm which is observed as a thin border around blastula.

peritoneum. Membranous lining of abdominal cavity.

perivitelline space. Fluid-filled space between egg proper and egg capsule.

pharyngeal teeth. Teeth on the pharyngeal bones of the branchial skeleton.

postanal myomeres. The number of myomeres between posterior margin of anus and the most posterior myoseptums.

preanal length. Method of measuring often not stated, assumed to be about equivalent to snout to vent length in larvae.

preanal myomeres. The number of myomeres between the anteriormost myoseptum and the posterior margin of anus.

predorsal scales. Scales along dorsal ridge from occiput to origin of dorsal fin.

prejuvenile. Developmental stage immediately following acquisition of minimum fin ray complement of adult and before assumption of adult-like body form; used only where strikingly different from juvenile (*cf.* Hubbs, 1958; *Tholichthys* stage of butterflyfishes, querimana stage of mullets, etc.).

premaxillary. The ventralmost of the two bones included in the upper jaw.

primordium. Rudimentary form of an anatomical structure; anlage.

principal caudal rays. Caudal rays inserting on hypural elements; the number of principal rays is generally defined as the number of branched rays plus two.

procurrent caudal rays. A series of much shorter rays anterior to the principal caudal rays, dorsally and ventrally, not typically included in the margin of the caudal fin.

pronephric ducts. Ducts of pronephric kidney of early developmental stages.

scute. A modified, thickened scale, often spiny or keeled.

sigmoid heart. The S-shaped heart which develops from the primitive heart tube.

SL. Abbreviation for standard length.

snout to vent length. Distance from anteriormost part of head to posterior margin of anus; the precise method of measurement often not stated.

soft rays. Bilaterally paired, usually segmented, fin supports.

somites. Primitive, segmented, mesodermal tissue along each side of notochord.

spines. Unpaired, unsegmented, unbranched fin supports, usually (but not always) stiff and pungent.

standard length. In larvae, straight-line distance from anteriormost part of head to end of hypural elements; not applicable to larvae prior to notochord flexion. (In juveniles and adults measured from most anterior point of snout or upper lip.)

stomodeum. Primitive invagination of the ectoderm which eventually gives rise to the mouth.

tail-bud stage. Stage of embryonic development characterized by a prominent caudal bulge and marked development of cephalic region.

tail-free stage. Stage of embryonic development characterized by separation of the tail from the yolk.

TL. Abbreviation for total length.

total length. Straight-line distance from anteriormost part of head to tip of tail; all older literature references not stated differently are assumed to be total length.

urostyle. Terminal vertebral element in higher teleosts, derived from the fusion and loss of several of the most posterior centra of the more primitive forms.

V. Abbreviation for the central or pelvic fin.

vent. Anus.

ventral fins. Paired fins articulating with the pelvic girdle; pelvic fins.

vitelline vessels. Arteries and veins of yolk region.

water-hardening. Expansion and toughening of egg capsule due to absorption of water into the perivitelline space.

width of perivitelline space. Distance between yolk and egg capsule expressed either as direct measurement or a ratio of the egg diameter.

xanthophores. Yellow chromatophores.

yolk. Food reserve of embryonic and early larval stages, usually seen as a yellowish sphere diminishing in size as development proceeds.

yolk diameter. Greatest diameter of yolk; more accurately measurable prior to embryo formation.

yolk plug. Yolk within the blastopore.

yolk sac. A bag-like ventral extension of the primitive gut containing the yolk.

yolk-sac larva. A larval fish characterized by the presence of a yolk-sac.

VOLUME VI DEDICATION

This volume is dedicated to Clark Hubbs who brought the science to life for both of us; and to Jerry D. Hardy, Jr., whose courage and persistence when too few people cared about fish larvae made this whole thing happen.

INTRODUCTION TO VOLUME VI

This sixth volume contains accounts of 65 species of telostean fishes (Stromateidae through Ogcocephalidae). The only species with confirmed records from our study area which have been left out with our knowledge are two *Symphurus* species mentioned in the cynoglossid family account. Other gaps undoubtedly exist that may be filled in future editions.

We depart from the standard series format in the following three features:

Flatfish larvae—rather than defining the end of the larval stage on the basis of adult fin ray complements we consider the stage as terminating when eye migration is complete.

Pleuronectid and soleid specimens are illustrated facing right to be consistent with adult eye placement.

Molid body length measurements—because hypural elements are apparently lacking, a measurement termed preclaval length is substituted for standard length (preclaval length defined in the Molidae family introduction).

Original unpublished contributions are indicated in the text by the initials of the contributor as follows:

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JCB John C. Briggs, University of South Florida, Tampa, Florida.
JHC John H. Caruso, Lafayette College, Easton, Pennsylvania.
GED George E. Drewry, Chesapeake Biological Laboratory, Solomons, Maryland.
RAF Ronald A. Fritzsche, Chesapeake Biological Laboratory, Solomons, Maryland.
RLH Richard L. Haedrich, Woods Hole Oceanographic Institute, Woods Hole, Massachusetts.
LAK Louis A. Krumholz, University of Louisville, Louisville, Kentucky.
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RHM Richard H. Moore, University of South Carolina, Coastal Carolina College, Conway, South Carolina.
JEO John E. Olney, Virginia Institute of Marine Sciences, Gloucester Point, Virginia.
ABP Allyn B. Powell, Atlantic Estuarine Fisheries Center, Beaufort, North Carolina.
TWP Theodore W. Pietsch, California State University, Long Beach, California.
TWR Timothy W. Robbins, Ichthyological Associates, Drumore, Pennsylvania.
FJS Frank J. Schwartz, University of North Carolina, Institute of Marine Sciences, Morehead City, North Carolina.
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NSS Nancy Schenk Smith, St. Petersburg, Florida.
WGS W. G. Smith, Northeast Fisheries Center, Highlands, New Jersey.
JCT James C. Tyler, Southeast Fisheries Center, Miami, Florida.
JWT John W. Tucker, Jr., University of North Carolina, Raleigh, North Carolina.
WW William Watson, North Carolina State University, Chapel Hill, North Carolina.

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In preparation of species accounts the family Batrachoididae was a joint effort; Drewry took primary responsibility for the families Mugilidae, Atherinidae, Molidae, Lophiidae, Antennariidae, Chaunacidae and Ogcocephalidae; and Martin took primary responsibility for the remaining families.

Peprilus paru
Peprilus triacanthus

butterfishes
Stromateidae

FAMILY STROMATEIDAE

This family is chiefly tropical and warm temperate in distribution and is largely restricted to continental shelves. Both species are in the genus *Peprilus*, as currently defined. This genus is found only in the New World. Both species are silvery, schooling fish most commonly encountered as adults in shallow nearshore waters. Juveniles are pelagic, accompanying jellyfish, *Sargassum* and flotsam. The deep-bodied *P. paru* is found from Massachusetts to Uruguay and throughout the West Indies. The less deep-bodied *P. triacanthus* occurs along the Atlantic coast of North America from Newfoundland to Florida, being replaced in the Gulf of Mexico by the closely related *P. burti*. Both species are commercially important, though the value of *P. paru* is considerably less than that of *P. triacanthus*.

Peprilus paru (Linnaeus), Harvestfish

ADULTS

D. II–IV [1] (III [3,6,8,10,12]), 38–49; [8] A. II–III, 35–45; [1] C. 19 principal rays, procurrent rays 8+8; [12] P. 18–24; [1] V. none, but pelvic bone visible through skin; [3] scales about 90; [10] vertebrae 13+17,[3] 15+15,[10] total 29–31,[1] modal number 30; [2] gill rakers 4–1–13 or 14,[6] total 14–16; [8] teeth minute, uniserial, compressed with 3 cusps; vomers, palatines and basibranchials toothless; gill membranes united across the isthmus.[3]

Proportions expressed as percent SL: 68–102 mm SL: body depth 64.3–70.1; head length 29.8–33.3; eye 10.3–12.3. 195 mm SL: body depth 66.6; head 28.0; eye 5.1.[6]

Body deep, compressed, anterior profile moderately or strongly convex,[2] mouth small, terminal or subinferior.[8] Scales very small, thin, cycloid, very deciduous and extending onto all fins. Lateral line with simple tubed scales, moderately high, following dorsal profile and extending onto peduncle but not onto caudal fin base.[3] Dorsal and anal fins moderately to extremely falcate.[2] Adipose tissue around eye developed, extending forward and surrounding the nostrils.[3]

Pigmentation: Greenish silvery above, lower sides plain silvery or with a tinge of yellow; dorsal and anal fins dusky, slightly yellowish in some specimens; caudal and pectoral fins slightly dusky or sometimes yellowish Color in preservative brownish, often with a silvery ove lay; back and sides sometimes with spots; gill cavit inside of mouth and peritoneum light.[3]

Maximum length: To 280 mm.[16]

DISTRIBUTION AND ECOLOGY

Range: Cape Elizabeth, Maine [2] to Uruguay includin the West Indies and the Gulf of Mexico.[3] Infreque north of Chesapeake Bay.[2]

Area distribution: Within Chesapeake Bay from A napolis to Cape Charles and Cape Henry,[8] New Jersey; [7] Sinepuxent Bay.[12]

Habitat and movements: Adults—pelagic,[6] most commo in areas with wide continental shelf and with large e panses of shallow water; [2] over mud, sand or infr quently over coral bottoms.[2] Inshore throughout th year but most commonly encountered in summer; [5] wit in Chesapeake Bay it migrates south for the winte Reported from salinities of 4 ppt to full sea water [13] an in temperatures from 11.7 to 30.0 C.[11] In the Atlantic occurs at depths of from 6 to 88 m and in the Gulf Mexico from 2 to 115 m,[2] most frequently encountere at 11 m or less.[14]

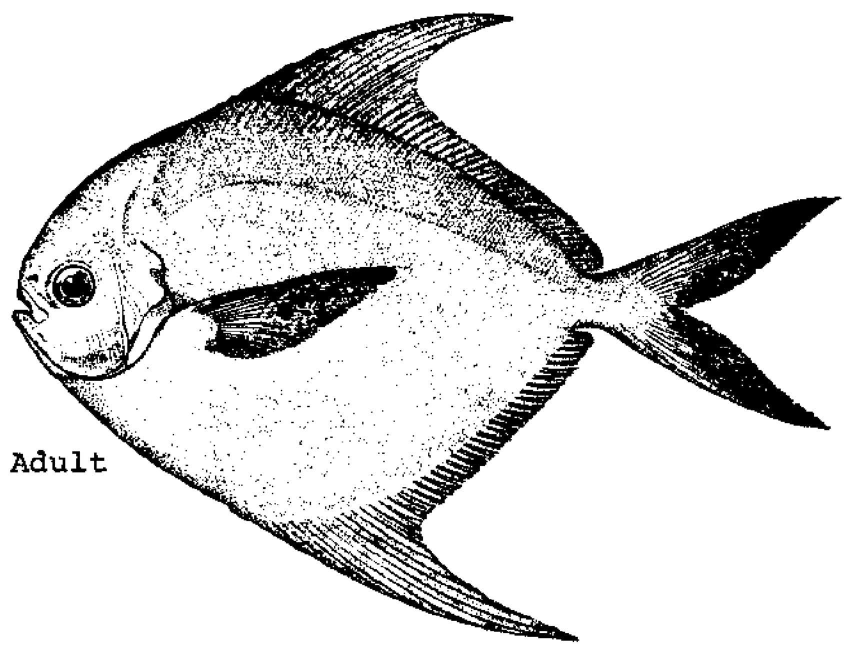

Fig. 3. *Peprilus paru*, Harvestfish. Adult. (*Hildebrand, S. F., and W. C. Schroeder, 1928: fig. 119.*)

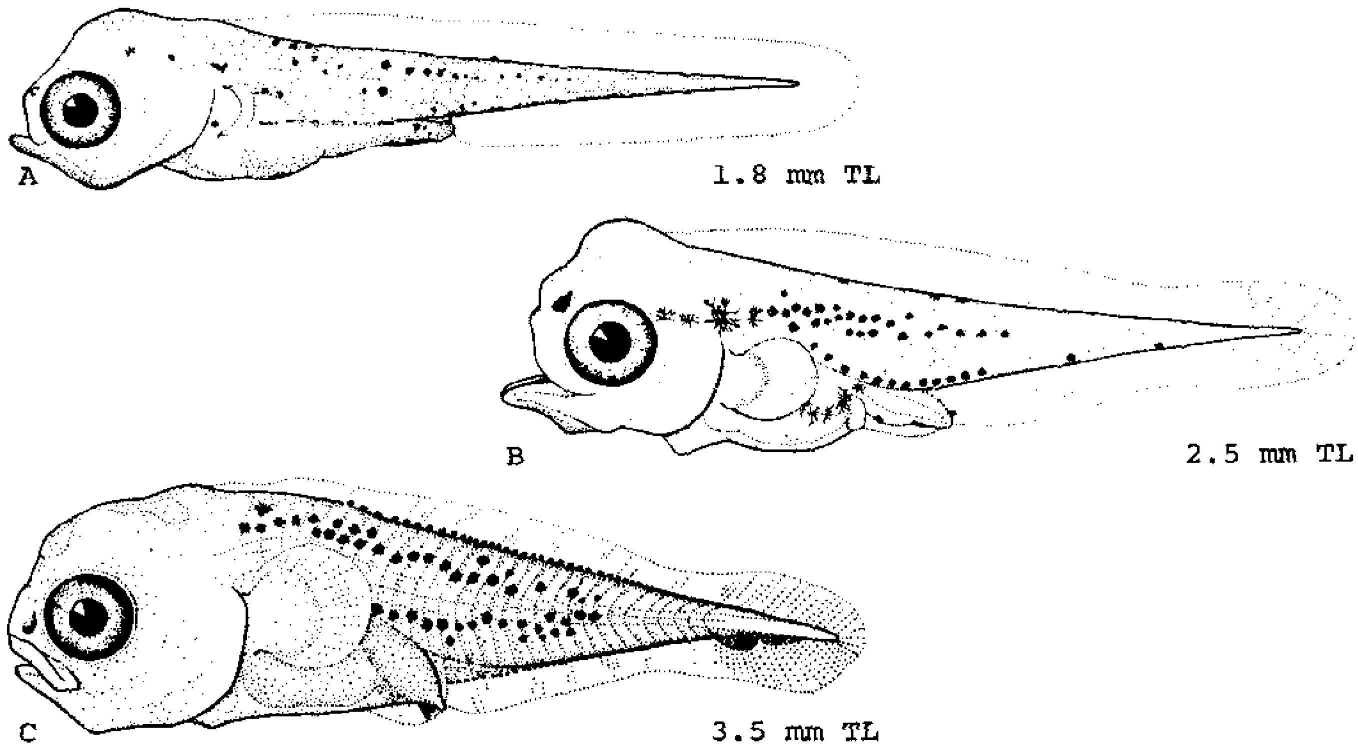

Fig. 4. *Peprilus paru*, Harvestfish. A. Larva, 1.8 mm TL. B. Larva, secondary anus in process of formation with primary anus still present, 2.5 mm TL. C. Larva, caudal elements forming, primary anus completely gone, 3.5 mm TL. (*A-C, Pearson, J. C., 1941: figs. 2, 3, 4.*)

Larvae—yolk-sac larvae essentially planktonic, nektonic at about 10–15 mm SL; [2] frequently associated with jellyfish.[2,17]

Juveniles—frequently associated with jellyfishes of the genera *Chrysaora*,[4] *Chiropsalmus*, *Cyanea*, *Aurelia* [2] and *Physalia*; [2,10] world-wide distribution of juveniles seems to be within the 20 C isotherm; [2] frequently encountered in estuaries.[4]

SPAWNING

Location: Offshore, generally.[2]

Season: In spring,[14] spring and early summer in lower Chesapeake Bay,[4] June and July.[10]

EGGS

Pelagic, near surface; [2] size about 1 mm.[2,8]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

1.8 mm TL to 7 mm.

Body becoming compressed at 3.5 mm TL; finfold entire from 1.8 to 3.5 mm TL but fin rays developing at 3.5 mm TL; gut elongate, about half body length at 1.8 mm, reduced in proportional length at 2.5 mm TL; two vents at 2.5 mm, the developing anterior one becoming the sole vent at 3.5 mm.[17]

Pigmentation: At 1.8 mm TL scattered melanophores on body; at 2.5 mm TL one series of melanophores on median line of body side from pectoral fins to about half body length, another more regular series lies along the lower side of body dorsal to gut; scattered anastomosed chromatophores above the opercle and along posterior side of abdominal cavity; melanophores appear to have moved dorsally somewhat at 3.5 mm TL.[17]

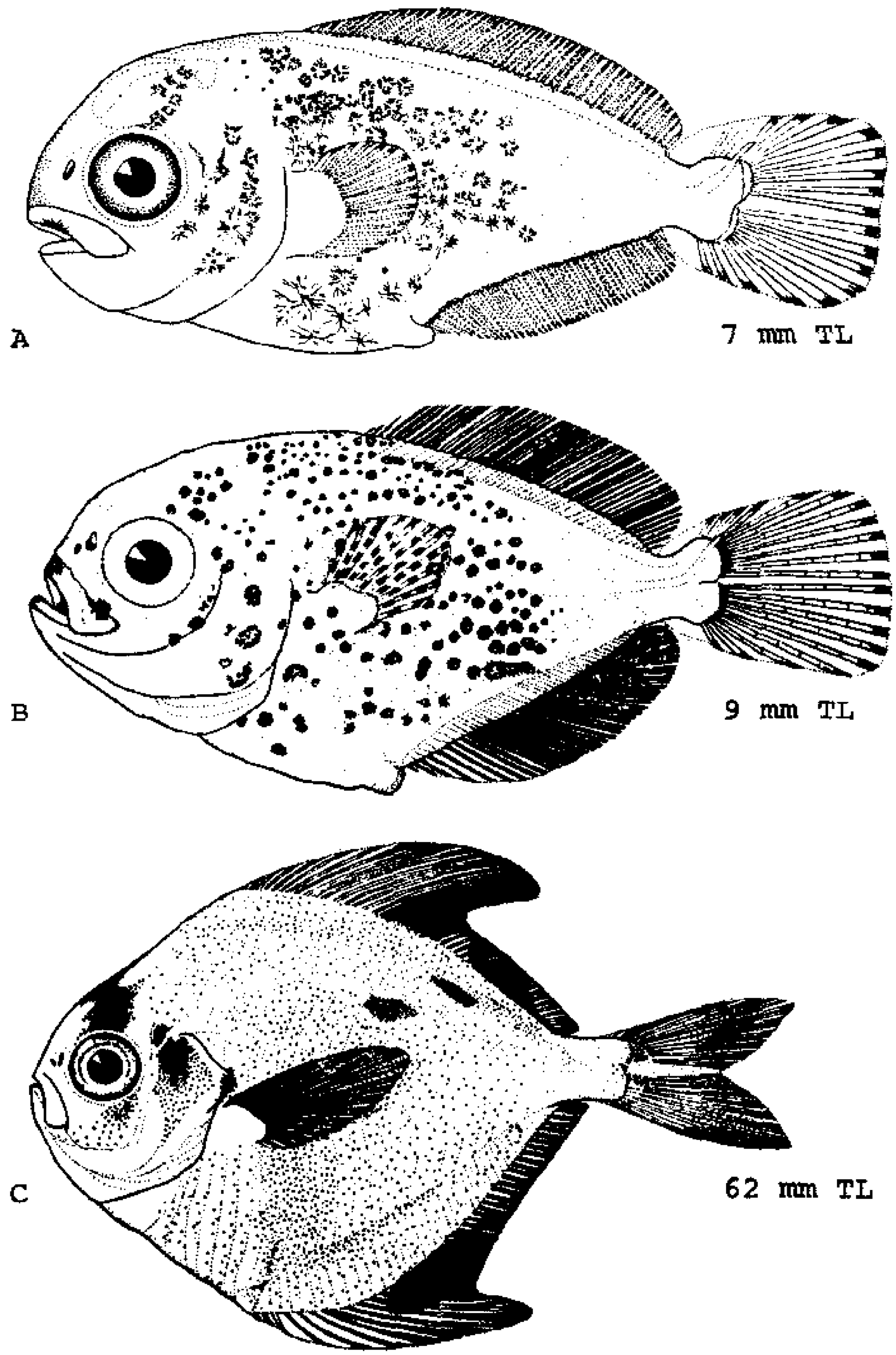

Fig. 5. *Peprilus paru*, Harvestfish. A. Larva, fin rays almost complete, 7 mm TL. B. Juvenile, chromatophores becoming condensed, more numerous, 9 mm TL. C. Juvenile, adult body form, black pigmentation more developed than in adult, 62 mm TL. (*A-C, Pearson, J. C., 1941: figs. 5, 6, 7.*)

JUVENILES

From 7 mm TL; body deeper at 7.0 mm TL, further compressed at 9 mm TL, strongly compressed, deep and oval at 62 mm TL; caudal fin forked at 62 mm TL.[27] Swim bladder regresses by 60–100 mm SL.[18]

Pigmentation: Chromatophores become scattered, enlarged and anastomosed, confined to forward part of body at 7.0 mm TL. At 9 mm TL pigment darkens and chromatophores smaller. At 62 mm TL thick peppering of black dots on sides; tips of dorsal and anal fins heavily pigmented.[17]

GROWTH

By August[8] 25–28 mm, 31–36 mm by September,[15] 100–125 mm by second year.[8]

AGE AND SIZE AT MATURITY

No information.

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Peprilus triacanthus (Peck), Butterfish

ADULTS

D. II–IV, 40–48; A. II–III, 37–44; [1] C. 19 rays; [12] P. 17–22; [1] V. none; vertebrae 13 + 19,[3] total 31–33,[2] 30–33, 17–20 caudal vertebrae, usually 19; [1] gill rakers about one-half length of gill filaments, about 18 on lower limb of first arch; [3] teeth minute, uniserial, laterally compressed with 3 subequal cusps, vomers, palatines and basibranchials toothless; [2,3] gill membranes united across isthmus.[3]

Proportions expressed as percent SL: Head length 25.1–35.8; snout length 5.5–9.0; pectoral fin length 17.9–36.4; maximum body depth 36.4–60.0; least depth of caudal peduncle 5.5–8.9.[2]

Body ovate, strongly compressed,[2,3,9] covered with very small, cycloid, thin, very deciduous scales extending onto all fins. Lateral line with simple tubed scales, moderately high, following the dorsal profile and extending onto the peduncle but not to caudal base.[3] Dorsal and anal fins slightly falcate.[2] Adipose tissue around the eye developed, extending forward and surrounding the nostrils.[3]

Pigmentation: Dorsum slaty-blue [8] or leaden-blue,[9,16] sides paler, belly silvery.[8,9,13] In preservative brownish, often with a silvery overlay.[3] Dorsal and upper ventral surfaces often mottled with dark spots; [1,2,12] gill cavity, inside of mouth and peritoneum light in preservative.[3]

Maximum length: To 305 mm,[10] usually 150–200 mm.[13] The largest Maryland specimen 254 mm.[28]

DISTRIBUTION AND ECOLOGY

Range: Off the Atlantic coast of North America from about 48° N in the Gulf of St. Lawrence to about 27° 30′ N off southern Florida. One stray reported from the Gulf of Mexico, northeast of Tortugas Light.[2]

Area distribution: New Jersey; [8,16] Delaware; [23,31] within Chesapeake Bay from Annapolis southward to the capes,[10,15] most common in lower Chesapeake; [10,14] Sinepuxent and Chincoteague Bays.[19,20]

Habitat and movements: Adults—northern populations usually over sand in summer,[9] rarely taken within a few hundred feet of shore.[14] South of Cape Hatteras there are two ecologically separated populations (species?); a deep water form which is shallower bodied, with 18–19 caudal vertebrae and frequently with spots, living over mud or silt down to 420 m and a shallow water form which is deeper bodied, with 17 or 18 (rarely 19) caudal vertebrae, with no spots, living over sand near shore.[2,36] Northern populations in summer move inshore to 25–55 m [2] or shallower,[22] and in winter move offshore to 180 m [2,3,9] to 210 m.[2] Within Chesapeake Bay movement is northward in the spring, appearing in Virginia waters in April, with none above the Rappahannock River before May; [10] stray fish in lower Chesapeake as early as March and they leave the bay by November; [10,14] around Long Island they are inshore from May to December; [21] populations around Georgia move inshore in colder months [26] while in Virginia waters they may be taken in pound nets in every season except early spring.[27] Reported from salinities of 5.0 ppt [14] to seawater, temperatures from 4.4 to 21.6 C, and from the surface to 250 m.[2]

Larvae—yolk-sac larvae essentially planktonic becoming nektonic at about 10–15 mm SL. After hatching they move inshore to bays and other protected waters, which serve as nursery grounds.[2]

Juveniles—frequently associated with jellyfish; [3,5] lose this association by about 30 mm SL; [2] remain inshore during summer at Woods Hole; [11] around Long Island they are common in the fall; [21,22] reported from salinities of 6.4 ppt [24] to seawater.[2]

SPAWNING

Location: Usually stated as being offshore,[2,3,15,32] but there is some circumstantial evidence indicating some nearshore spawning activity in Narragansett Bay [7] and in Long Island Sound.[25]

Season: Spawning occurs in June, July and August,[2,13] sometimes continuing into September; [32] spawning peaks are in July in Canada,[9] June and July in New England [32] and around Long Island,[6] and in late spring or early summer in Chesapeake Bay.[2,27]

Temperature and salinity: Eggs are found at 12.8–22.5 C [7] and in 78–100% seawater.[2]

EGGS

Location: Pelagic,[3,29] probably deposited by a mass extrusion of sexual products.[2]

Fertilized eggs: Size variously reported as .7–.8 mm,[29,35] .68–.82 mm,[7] .69–.80 mm with a mean of .75 mm; [33] .75–.79 mm; [2,17,18] yolk unpigmented; [17,34,35] oil droplet single in 70% of eggs, 2 or 3 in others; [2,7] oil droplet diameter where there is only one, .17–.20 mm [29] or .17–.21 mm,[15,18] where there are two or three droplets, diameters range from .06 to .16 mm; [18] average of one set of data was .18 mm with a range from .14 to .22.[33]

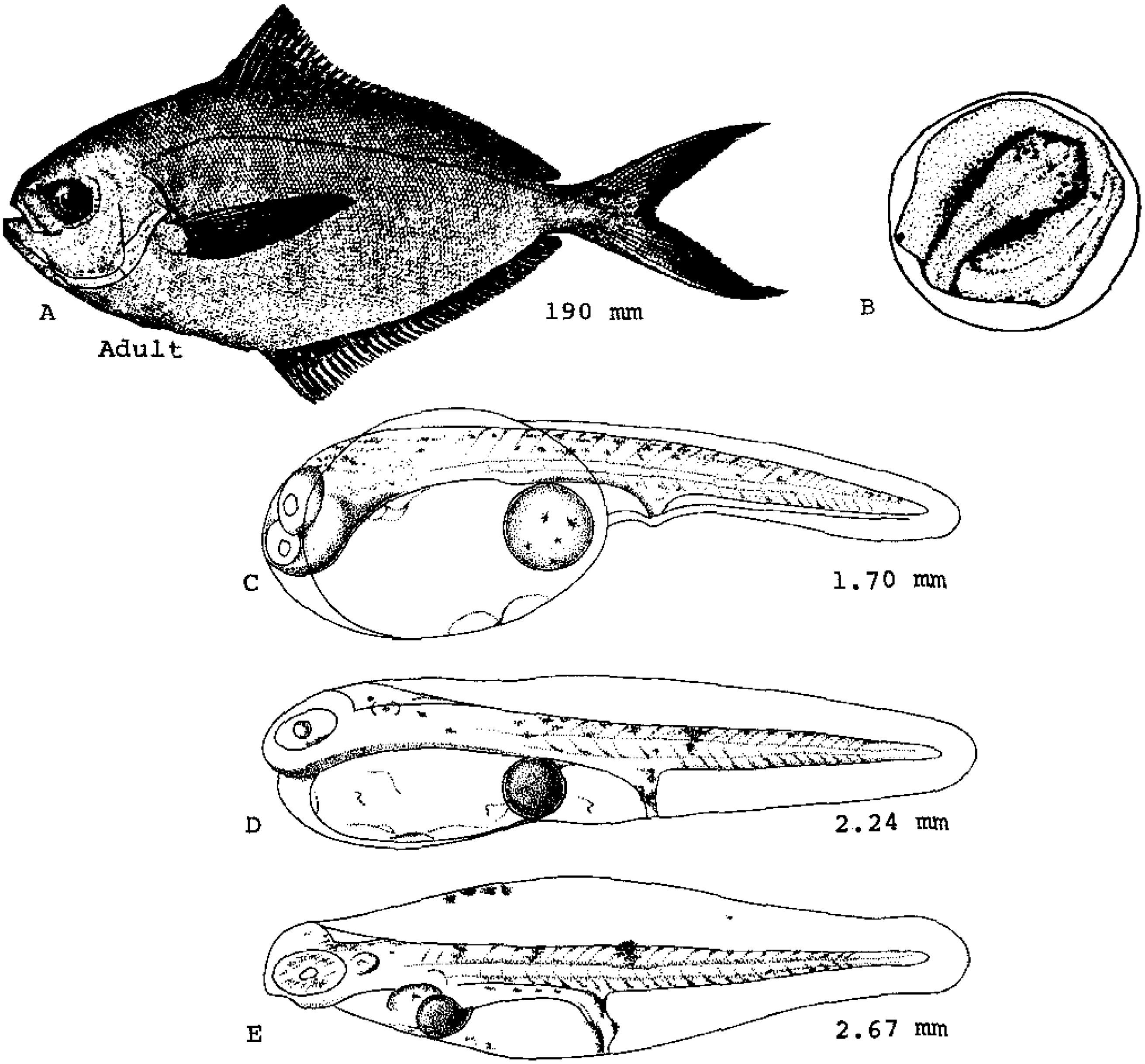

Fig. 6. *Peprilus triacanthus*, Butterfish. A. Adult, 190 mm. B. Egg, diameter unstated. C. Newly hatched yolk-sac larva, 1.70 mm. D. Yolk-sac larva, 2.24 mm., 24 hours after hatching. E. Late yolk-sac larva, 2.67 mm, 72 hours after hatching, yolk mass nearly gone, eye becoming pigmented. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 405. B, Perlmutter, A., 1939: fig. 2. C-E, Colton, J. B., Jr., and K. A. Honey, 1963: fig. 1, delineated by Elizabeth Ray Peters. Figure C reversed.*)

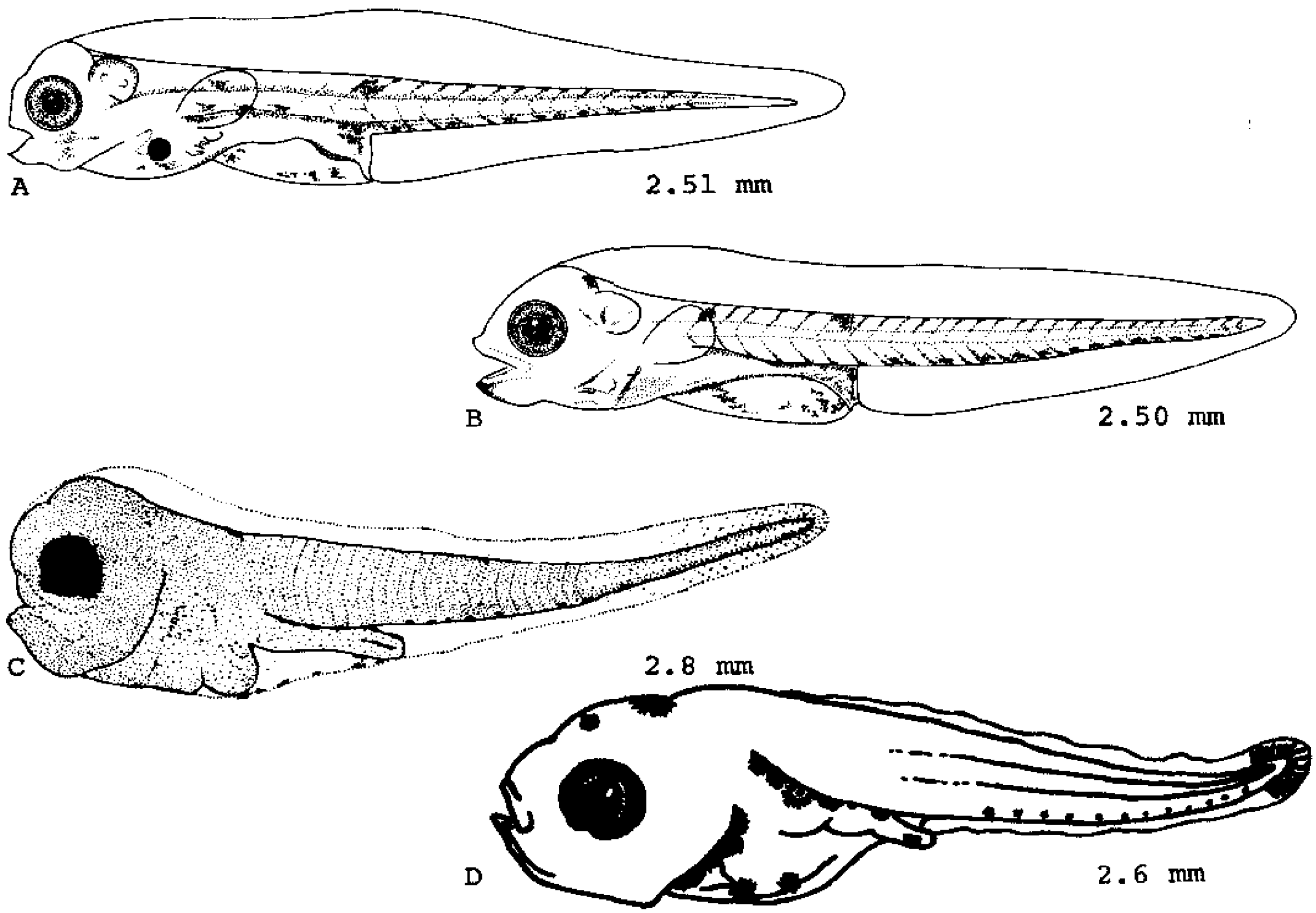

Fig. 7. *Peprilus triacanthus*, Butterfish. A. Late yolk-sac larva, 2.51 mm, 144 hours after hatching, oil droplets still visible, eye pigmented. B. Larva, 2.50 mm, 168 hours after hatching. C. Larva, 2.8 mm, head profile becoming more gently sloping, pectoral fin not shown, but probably present. (*A-B, Colton, J. B., Jr., and K. A. Honey, 1963: fig. 1, delineated by Elizabeth Ray Peters. C, Perlmutter, A., 1939: fig. 2. D, Miller, D., 1958: 4.*)

EGG DEVELOPMENT

At 13.3–16.3 C, average of 14.6 C:
- 24 hours—blastodermal cap completed.
- 48 hours—blastopore closed or closing, eye becoming differentiated.
- 56 hours—tail formed and light scattered pigment appeared on oil globule and on dorsum of embryo from an area just posterior to eyes and extending in two rows to end of tail.
- 72 hours—about 50% of eggs hatched.[18]

Somites differentiated before tailbud.[34]

Incubation period: 2 days at 18.3 C,[3] 48–72 hours at an unspecified temperature,[2] while only 50% were hatched at 72 hours at an average temperature of 14.6 C.[18]

YOLK-SAC LARVAE

At hatching 2 mm,[2] or average 1.72 mm at hatching with a range of 1.68 to 1.75 mm,[17,18] yolk absorption complete at 2.48–2.64 mm (average 2.60 mm).[18]

Eyes unpigmented prior to yolk sac absorption; finfold arched at about 2.49 mm (48 hours post-hatching);[18] anus located a short distance from posterior margin of yolk sac and a little behind midpoint of body on margin of finfold;[17] gas bladder present.[4]

Pigmentation: Sparse at hatching, confined to dorsal and dorsolateral surfaces of body in two rows of small melanophores extending from head to tail. Within 48 hours of hatching a row of fine melanophores appears along body at base of ventral finfold posterior to vent.

but it is not until shortly before complete yolk sac absorption that the characteristic ventral melanophores are pronounced. At 24 hours post-hatching the melanophore patterns change little with the principal coloration being from yellow-brown chromatophores confined to anterior two-thirds of body. At 48 hours post-hatching, yellow-brown pigmentation on the dorsum just posterior to vent and at vent becomes more distinct, while yellow-brown pigment spots begin to appear on dorsal finfold. At 72 hours, yellow-brown pigment spots on dorsal finfold more distinct. At 96 hours, yellow-brown spots on the dorsal finfold begin to decrease in size.[17,18,34]

LARVAE

Range from 2.6 mm [18] to 16 mm.[30]

A total of 30 myomeres easily discernable at 168 hours post-hatching [18] and two-thirds of the vertebral column is ossified by 6–7 mm, even though *the head is still* incompletely ossified. Body shape deep [17] or stout; [30] mouth well-developed at 120 hours post-hatching (average length is 2.6 mm). Upper part of eye becomes pigmented at about 120 hours post-hatching; eye nearly completely pigmented by 144 hours post-hatching.[18] Branchiostegals noticeable at 3.7 mm; [35] dorsal and anal

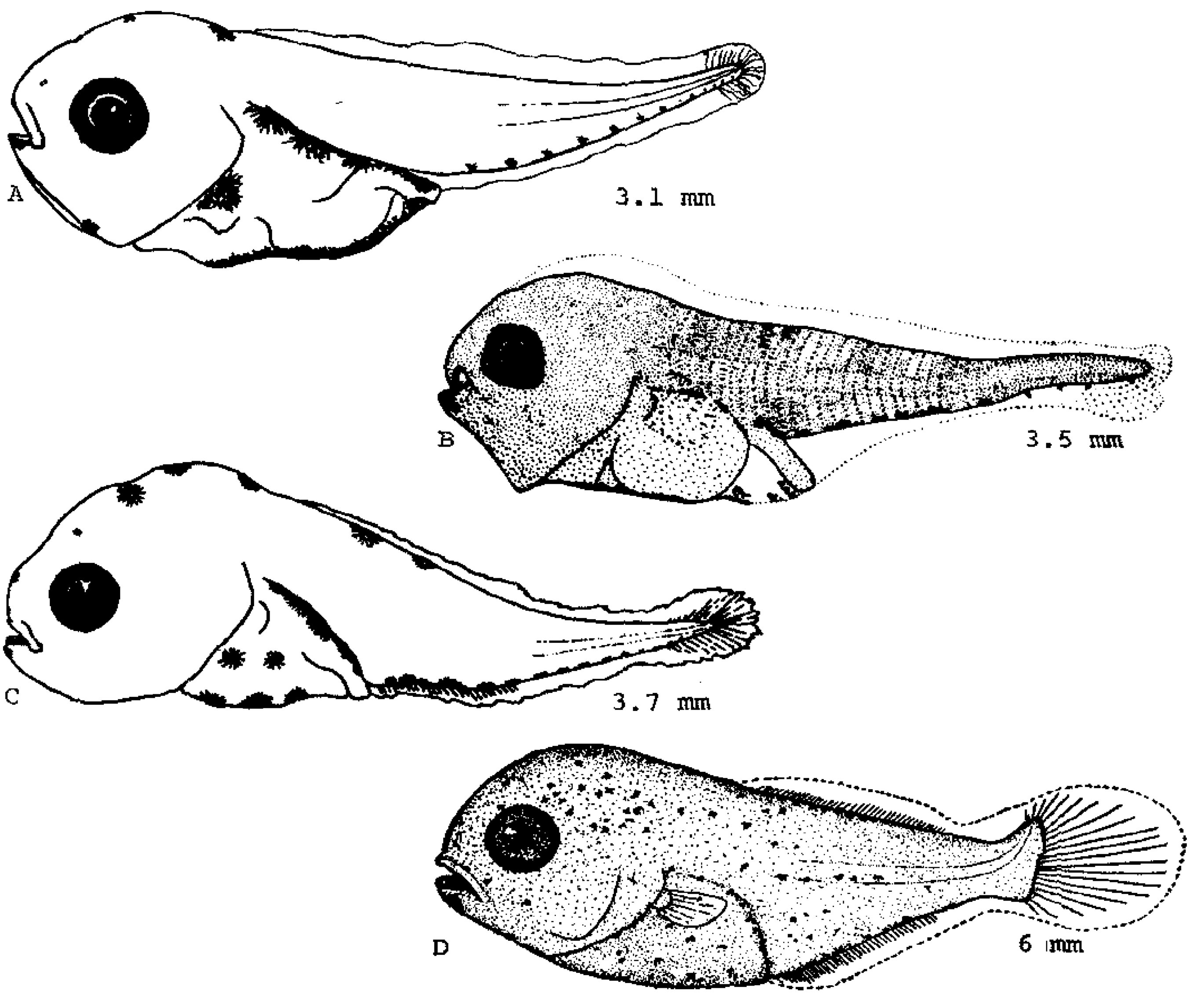

Fig. 8. *Peprilus triacanthus*, Butterfish. A. Larva, 3.1 mm. B. Larva, 3.5 mm. C. Larva, 3.7 mm, anal rays forming. D. Larva, 6 mm, dorsal rays forming. (*A, C, Miller, D., 1958. B, Perlmutter, A., 1939: fig. 2. D, Hildebrand, S. F., and W. C. Schroeder, 1928: fig. 124.*)

fin rays becoming discernable at 5 mm;[17,35] ossification begins at about 8–10 mm, and by 12–18 mm all rays are visible;[2] caudal fin rays begin developing at 3.7 mm,[35] 5 mm[17] or 7 mm;[30] at 8–10 mm, the epural elements unossified while hypural elements are more completely ossified; at 12–18 mm, epural elements the only unossified elements of the caudal skeleton and the hypurals have moved into a more symmetrical position, urostyle more slender and the fin beginning to fork; at 5 mm SL, hypural plate as ossified and fused as in adult;[2] pectoral fins present at 6–7 mm.[2,30]

Pigmentation: At 120 hours post-hatching, predominant color yellowish brown;[18] a distinct ventral row of melanophores,[17,18] and yellowish brown pigment spots on dorsal finfold decreased in size and number, or disappeared. At 144 hours post-hatching, yellow-brown pigment either less prominent or has disappeared, eyes blue;[18] melanophores above the intestine and along ventral aspect of tail increased in size and very distinct.[17,18] At 168 hours post-hatching, pigmentation essentially unchanged.[18] In addition to pigmentation mentioned, there are two large, stellate menaphores on top of head, large scattered melanophores on ventral margin of gut and one or more melanophores along posterior margin of opercle;[17] by 7 mm eye has taken on a greenish brown metallic luster.[30]

JUVENILES

16 mm[30] to about 120 mm.[2]

At 15 mm body shape beginning to take on general appearance of adult body;[11] by 16 mm caudal fin slightly forked;[2] gas bladder present in juveniles, regressing by 100 mm SL.[4,37]

Pigmentation: At 16 mm whole body slightly tinted with yellowish brown, head and anterior part of the body being darkest with patches of carmine between eye and brain; upper part of head, anterior part of lateral line and flanks of the body well covered with large, closely packed, dendritic chromatophores; large and more distinct chromatophores cover sides of body behind digestive cavity; a row of longitudinal pigment bars extends along whole base of dorsal fin, while delicate dendritic cells extend along base of the anal and caudal fin rays.[30]

GROWTH

Growth rates reported vary from 76–127 mm in one year[13] to 102–133 mm by October of the first year;[10] modal sizes in June are 0–4 mm, July–August 0–4 mm and 5–9 mm, September 15–19 mm and 35–39 mm and October 70–74 mm;[6] early-spawned individuals are 76–102 in the fall while late-spawned individuals are 51–76 mm in fall and 76–127 in the following spring;[13] largest first year growth rate reported is a modal size of 100 mm or slightly less in October;[22] reported to reach 150 mm at 2 years of age.[10]

AGE AND SIZE AT MATURITY

Probably 2 years[2,3] and 120–180 mm SL,[2] 145 mm,[10] or 178 mm.[3]

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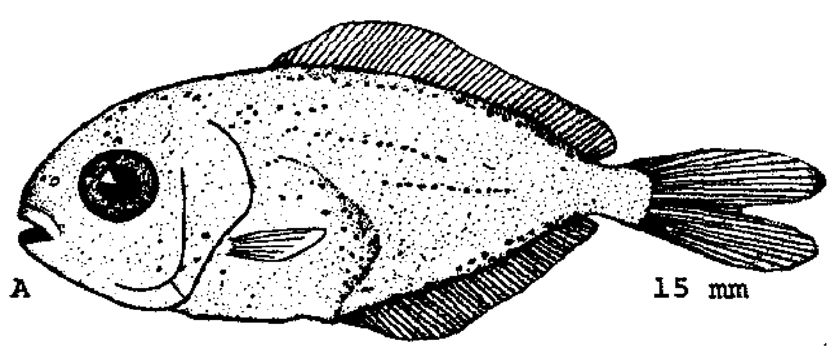

Fig. 9. *Peprilus triacanthus*, Butterfish. A. Juvenile, 15 mm. (*Hildebrand, S. F., and W. C. Schroeder, 1928: fig. 125.*)

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Hyperoglyphe perciforma

ruffs and barrelfishes
Centrolophidae

FAMILY CENTROLOPHIDAE

Most species in this family are pelagic offshore species. The barrelfish is thought to be deep-living over the continental slope and in submarine canyons as an adult (RLH), while the juveniles are epipelagic, closely associated with flotsam. Juveniles often drift quite close inshore so that in waters of this region the adult will be seldom, if ever, encountered while the juvenile may be common on occasion. Juvenile barrelfish seem to be more abundant just north of the area than within it.

Hyperoglyphe perciforma (Mitchill), Barrelfish

ADULTS

D. VI [5,7]–VIII; [2,3,5,7] 19 [2]–23,[12] first two spines almost embedded in the skin of larger specimens; [5] A. III, 15–17; [2] P. 18–22; [1] V. I, 5; [4] scales 89–95; [1] vertebrae 10 [2,4] + 14–15; [4] gill rakers 5–7 + 1 + 15–17.[2]

Proportions expressed as percent SL: Head length 27.8–30.0; snout 6.8–7.9; eye length 5.9–6.8; body depth 38.3–41.8.[12]

Body stout, oblong and moderately compressed,[5] covered with moderate size, somewhat deciduous, cycloid *scales; bases of median fins covered with scales; lateral* line arched anteriorly, straightening out over the middle of anal fin and extending on to peduncle; caudal peduncle broad.[2] Origin of dorsal fin just behind level of gill opening, termination at beginning of caudal peduncle, spinous portion much lower than rayed portion; caudal fin slightly forked.[5]

Pigmentation: Specimens caught near the surface are brownish black with iridescent green flecks over the lateral-ventral body surface; specimens taken from 125–214 m were brownish black dorsally, grading to a brownish white ventrally, with one specimen having a golden tint blended with the brown on the caudal peduncle.[12]

Maximum length: Deep water specimens to about 910 *mm;* [3] *largest reported surface specimen 745 mm.*[12]

DISTRIBUTION AND ECOLOGY

Range: Southwestern edge of Grand Bank and inshore waters of Halifax, Nova Scotia to off Key West, Florida; [5] one specimen reported from Penzance Harbor, Cornwall, Great Britain.[7]

Area distribution: Upper and *lower* Chesapeake Bay,[9] Ocean City, Maryland,[11] Atlantic, Cape May, Monmouth and Ocean counties, New Jersey.[8]

Habitat and movements: Adults—pelagic [2,3,5,7,12] or bathypelagic [13] occasionally associated with flotsam; found from near surface [12] to depths as great as 183 m [6] *or 244 m.*[3]

Larvae—no information.

Juveniles—occur under flotsam, but not usually under jellyfish, in surface waters near the edge of the continental shelf.[2] Common inshore around Massachusetts during the summer.[11]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

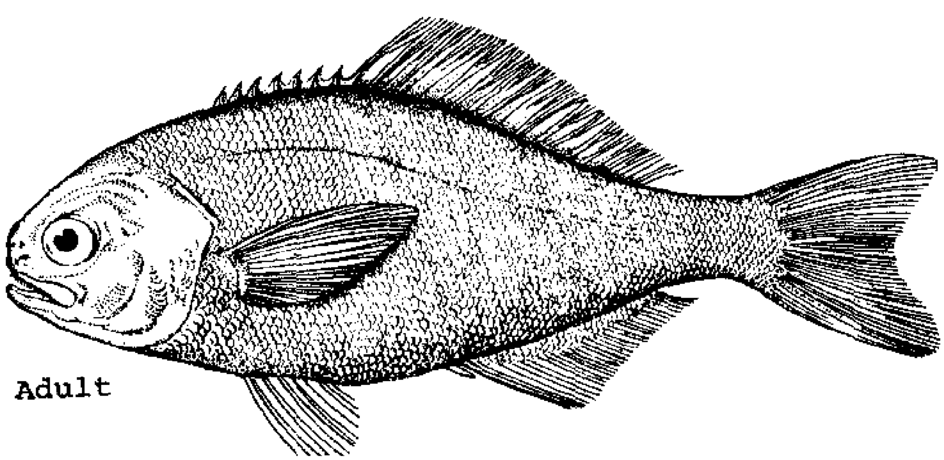

Fig. 10. *Hyperoglyphe perciforma*, Barrelfish. Adult, length unstated. (*Leim, A. H., and W. B. Scott, 1966: 331. © Fisheries Research Board of Canada. Used with permission of authors and publisher.*)

JUVENILES

A 20 mm SL specimen from Puerto Rico, possibly of this species, had a dark brown, almost black dorsum; sides and venter were grayish white with 3 bars of the same color as the back extending down on the sides for about 3/4 of the body depth, these bars triangular, narrowing to a blunt point ventrally (FDM). This specimen could be a misidentified *Centrolophus* or *Schedophilus* (RLH).

GROWTH

Based on presumed annuli at 1+ years a length of 271.0 mm and a weight of 521 g; at 2+ years a length of 441.0 mm and a weight of 2555 g; at 4+ years a length of 627.0 mm and a weight of 7407 g; and at 10+ years a length of 658.0 mm and a weight of 8327 g.[12]

AGE AND SIZE AT MATURITY

No information.

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Tetragonurus atlanticus

squaretails
Tetragonuridae

FAMILY TETRAGONURIDAE

This family is nearly cosmopolitan in warm seas and is primarily oceanic. The species, *Tetragonurus atlanticus*, is nearly cosmopolitan and in continental North American waters is more common off California than off the Atlantic coast. The adults are thought to be meso- or bathypelagic while the juveniles are epipelagic, forming associations with coelenterates and salps. Though infrequently seen in collections, this species may well be abundant (Grey, 1955). Larvae of this family differ from most other stromateoid larvae in that the pelvic fin is the last fin to initiate development rather than the first (Ahlstrom, Butler and Sumida, 1976).

Within the genus *Tetragonurus*, *T. atlanticus* is most readily distinguished from *T. cuvieri* by its vertebral number (44–46 as opposed to 51–54).

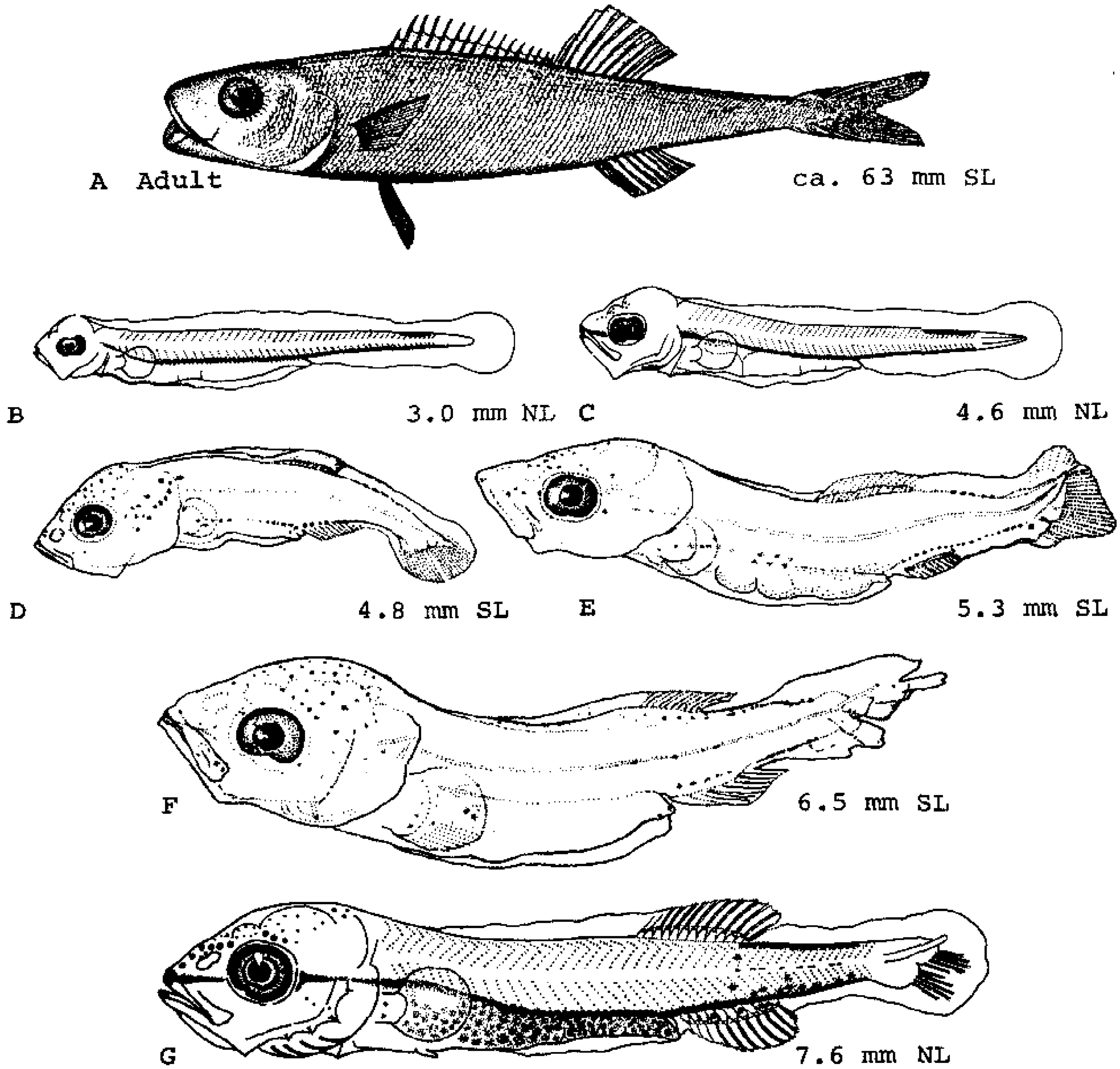

Fig. 11. *Tetragonurus atlanticus*, Bigeye squaretail. A. Adult, ca. 63 mm SL. B. Larva, 3.0 mm NL, eastern Pacific. Note the dorsal, caudal, and ventral pigment lines. C. Larva, 4.6 mm NL, eastern Pacific. Note preorbital pigment band. D. Larva, 4.8 mm SL, western Pacific. Early flexion larva, note lack of preorbital pigment and weakness of development of dorsal, caudal, and ventral pigment lines. E. Larva, 5.3 mm SL, Atlantic. Early flexion occurring. F. Larva, 6.5 mm SL, Indian Ocean. Flexion occurring. G. Larva, 7.6 mm, eastern Pacific. Flexion occurring. Pigment lines still well developed. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 411. B-C, G, Ahlstrom, E. H., J. L. Butler, and B. Y. Sumida, 1976: figs. 11A, 11C. D-F, Grey, M., 1955: figs. 8A, 8B, 8C.*)

Tetragonurus atlanticus Lowe, Bigeye squaretail

ADULTS

D. XIV to XVII,[1] 9[10]–13[1] or XV to XXI–I, 11–13;[5] A. II,[10] 9–11[9] or 10–12;[1,5] P. 17;[9] V. I, 5, inner ray adnate to abdomen; C. 9–10 + 9 + 8 + 9–10;[9] or 11 + 8 + 7 + 10[10] scales 83–95[1] or 118–120;[5] branchiostegals 6; vertebrae 45–51[1] or 23–24 + 20–22 = 44–46;[9] teeth in a single row, long, narrow and compressed, $\frac{27\text{–}40}{50\text{–}60}$,[1] teeth developed on the blade of the vomer, palatine teeth in a single row per side.[9]

Proportions expressed as percent SL: Head length 26–42 (decreasing with age); orbit 8–14 (decreasing with age);

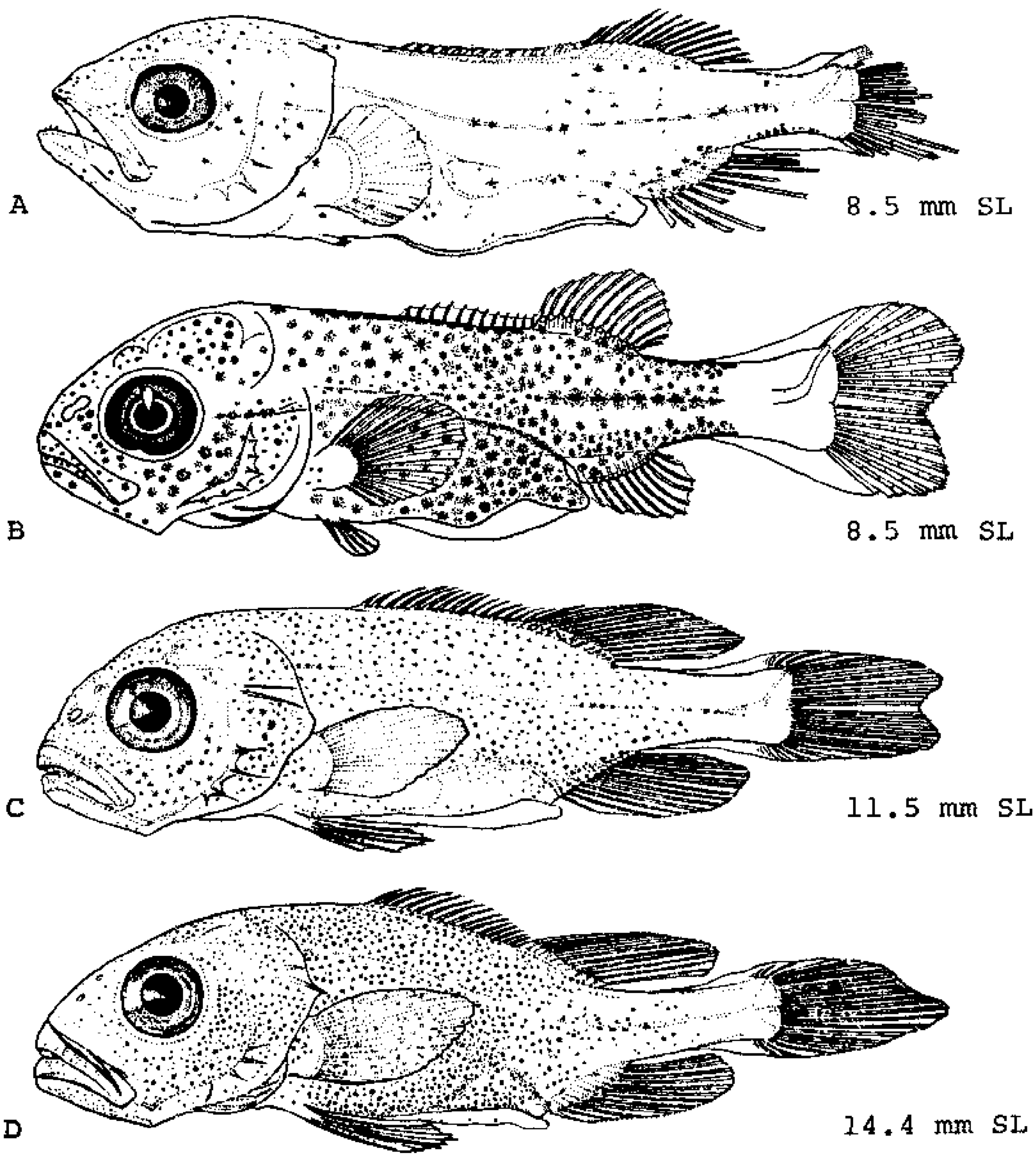

Fig. 12. *Tetragonurus atlanticus*, Bigeye squaretail. A. Larva, 8.5 mm SL, Atlantic. Note relative lack of melanophores. B. Larva, 8.5 mm SL, eastern Pacific. Note larger number of melanophores on sides than equivalent sized Atlantic specimens, also, more preopercular spines and more highly developed pelvic and pectoral fins. C. Larva, 11.5 mm SL, Atlantic. D. Juvenile, 14.4 mm SL, Indian Ocean. (*A, C-D, Grey, M., 1955: figs. 8D, 8E, 8F. B, Ahlstrom, E. H., J. L. Butler, and B. Y. Sumida, 1976: fig. 11D.*)

body depth 15–36 (decreasing with age); pelvic fin 7–22 (decreasing with age); length of longest dorsal spine 4–13 (decreasing with age).[1]

Body elongate, slender. Scales keeled, close-set, adherent; scales reduced in size anteriorly in head region. Lateral line may be slightly curved anteriorly descending gradually to middle of body, ending at origin of caudal keel.[1]

Pigmentation: Color in preservative uniformly brown, ranging from tan to almost black with fins same color as body; inside of mouth and peritoneum dark.[1]

Maximum length: 266 mm.[1]

DISTRIBUTION AND ECOLOGY

Range: Atlantic, Caribbean, Indian and Pacific oceans. In the western Atlantic reported from off Nova Scotia and Massachusetts to the Caribbean.[1] Taken inshore once from around Woods Hole[4,5,6] and from Vineyard Sound,[4] possibly *T. cuvieri* (RLH).

Area distribution: Not definitely known from this area but Grey's maps and distributional data indicate that it probably occurs here along the edge of the continental shelf.[1]

Habitat and movements: Adults—probably bathypelagic[5] moving shoreward for spawning;[5,6] occasionally associated with salps and flotsam.[4]

Larvae—taken in open ocean from 10–1000 m with most specimens being taken between 50 and 150 m and at temperatures between 19.0 and 26.4 C.[1]

Juveniles—occasionally associated with flotsam[4] or salps and jellyfish at the surface.[2,7]

SPAWNING

Location: At the surface[1] and near land.[5]

Season: Spawning season uncertain but small specimens are only taken between August and October in the east Atlantic and open ocean of the north central and northwestern Atlantic. In the Sargasso Sea, Caribbean and off South Africa larvae have only been taken from January to April.[1]

EGGS

Pelagic, separate; spherical, diameter 1.10 mm; chorion unsculptured, golden in color with a touch of pink; yolk unsegmented; perivitelline space moderate; single oil droplet, 0.24 mm in diameter.[9]

EGG DEVELOPMENT

Embryo with characteristic heavy pigment extending from just behind head to tip of notochord situated above digestive tract anterior to anus and along ventral midline of tail posterior to anus; dorsal pigment consists of a short, posterior streak ending before terminal myomere; a patch on snout.[9]

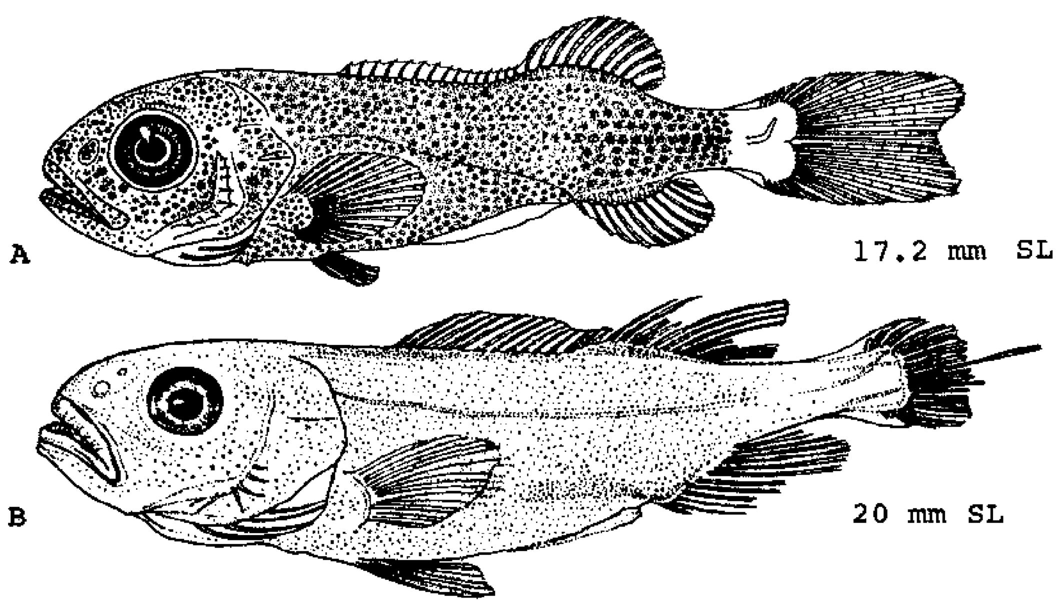

Fig. 13. *Tetragonurus atlanticus*, Bigeye squaretail. A. Juvenile, 17.2 mm SL, eastern Pacific. B. Juvenile, 20 mm SL, eastern Pacific. (*A, Ahlstrom, E. H., J. L. Butler, and B. Y. Sumida, 1976: fig. 11E. B, Grey, M., 1955: fig. 9A.*)

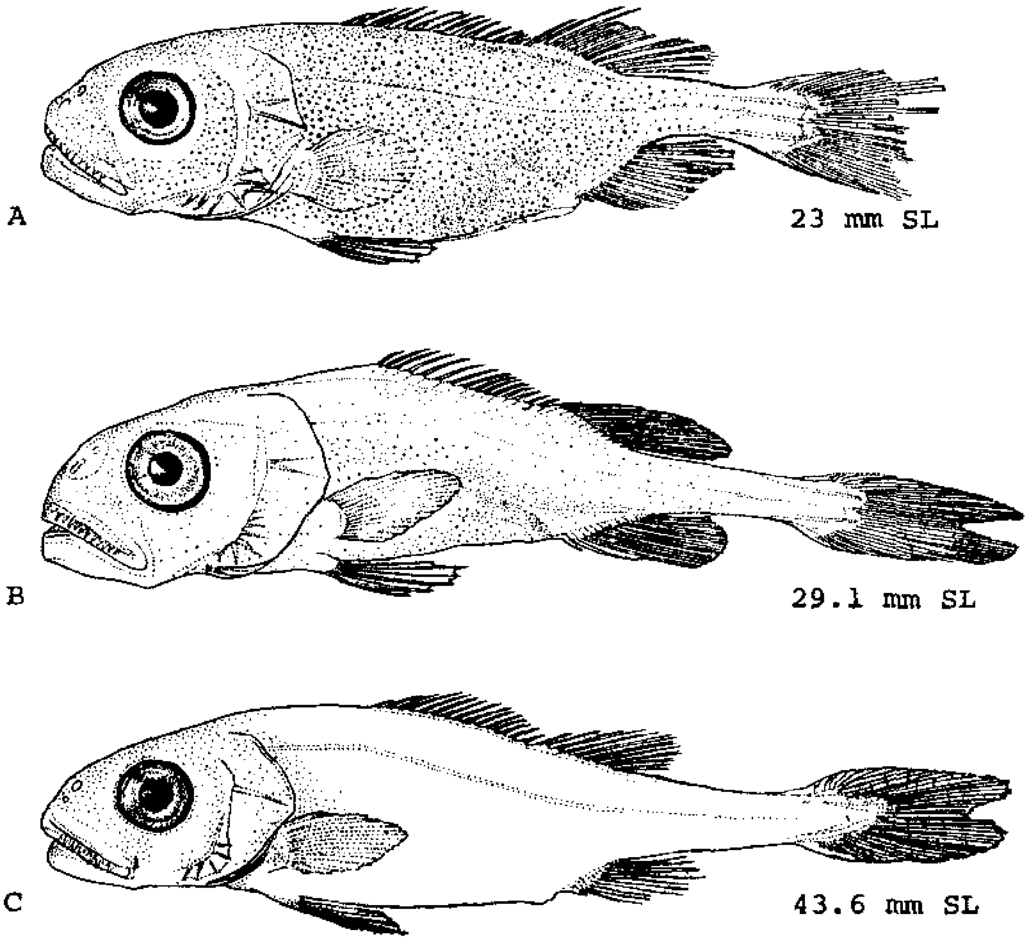

Fig. 14. *Tetragonurus atlanticus*, Bigeye squaretail. A. Juvenile, 23 mm SL, eastern Pacific. B. Juvenile, 29.1 mm SL, Indian Ocean. C. Juvenile, 43.6 mm SL, Atlantic. (*A-C, Grey, M., 1955: figs. 9B, 9C, 9D.*)

YOLK-SAC LARVAE

3.0–3.3 mm at hatching, yolk sac absorbed by 4.4 mm (5 lays post-hatching).[8]

Pigmentation: A continuous line of ventral pigment on ither side of body extending from head to tip of notochord; forward of anus this line over gut; dorsal pigment imited to a single median line on last 8–12 myomeres xtending to tip of notochord; pigment around developng mouth and scattered below yolk sac and gut.[9]

LARVAE

Reported from 3.0 mm NL to 17.2 mm SL.

Myomeres 44–46, vertebrae 23–24 + 20–22.[9] Dorsal fin at 5.3 mm with no spines or rays formed, spines forming by 3–10 mm; anal fin at 5.3 mm with rays not formed, by 10–11 basal elements forming; pelvic fins absent at 5.3 mm, appear at about 6 mm and rays forming at 8.5 mm; no scales at 5.3 mm; about 45 myomeres; 1 premaxillary tooth present at 5.3 mm, 3 minute teeth on each side of upper jaw at 8.5 mm; finfold uniform, high on peduncle, reaching dorsal and anal fins, extending forward to about even with pectoral fins at 5.3 mm, at 8.5 mm about same except ending short of anal fin; urostyle straight at 5.3 mm,[1] flexion occurring at 7.6 mm NL.[9]

Head length 14% NL at 3.3 mm NL, 26% NL at 4.2 mm NL, 27–30% NL during flexion and 30–35% SL after flexion; eye diameter 28–34% HL; snout length 24–29% HL between 4.2 mm NL and 17.2 mm SL; snout-vent length 63–71% SL, $\bar{x}$ 67% SL; body depth 13–20% NL preflexion; 20% NL during flexion; 24–28% SL after flexion.[9]

By 8.0 mm SL 31 vertebrae ossified and all vertebrae ossified by 10.5 mm SL; all branchiostegal rays ossified by 7.2 mm NL; gill rakers appear on lower arch at 8.0 mm SL; 3 small spines on outer margin of preopercle at 7.2 mm NL; increasing to 8 by 17.2 mm SL; premaxillary and dentary teeth first appear at 7.2 mm NL with dentary teeth being longer, broader and more blade-like than those on premaxillary; scales evident at 17.2 mm SL.[9]

Pigmentation: Preflexion larvae with a sparse sprinkling of small brown spots on top of head, snout and cheeks,[1,9] may have line from snout to anterior margin of eye,[9] spots present also on abdomen (heaviest concentration on anterior upper part of alimentary tract), ventral edge of tail, and faintly, on dorsal surface of tail; end of caudal peduncle behind base of urostyle entirely colorless;[1,9] midline of body conspicuously colorless and transparent.[1]

Postflexion larvae with a sparse scattering of chromatophores on head; abdomen fairly well pigmented with a sprinkling of larger spots; vent colorless; sides with spots from a vertical between the vent and origin of the soft dorsal to about middle of caudal peduncle, the latter of which has no lateral pigment; spots continue along dorsal and ventral edges of peduncle nearly to caudal fin;[1] end of peduncle and caudal fin essentially colorless;[1,9] one spot of pigment on each anal ray; other fins colorless.[1]

JUVENILES

All fin ray complements complete at sizes above 10 mm.

D. XV to XVI, 10–12 for 12 mm juveniles; A. I, 10–11 for 12 and 20 mm juveniles; pelvic fins well developed at 12 mm, pectoral fins with 18 rays at 20 mm; scales appear first on opercle at 14.6 mm, about 6 rows on caudal peduncle and several short rows on side, scalation complete by 26.5 mm; myomeres 44 at 12 mm; gill rakers 9+4 at 20 mm; at 20 mm small flaps of finfold remain just in front of vent and above and below on caudal peduncle at base of caudal fin; scale ridges represented only by single spines at 20 mm;[1] gas bladder present in early juveniles but resorbed by 50 mm.[3]

Pigmentation: Generally dark colored, a complete lack of pigment beyond base of urostyle.

12 mm: Abdomen darker than rest of body, a few linear marks on the midline of tail, bases of anal rays brownish.

20 mm: Generally dark, head and end of peduncle lighter; dark pigment spots end abruptly on tail, the latter one-third having no pigment at all; several spots on each dorsal spine; basal one-third of dorsal and anal fin rays heavily spotted; caudal fin entirely colorless.[1]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Sphyraena barracuda
Sphyraena borealis
Sphyraena guachancho

barracudas
Sphyraenidae

FAMILY SPHYRAENIDAE

This family is represented by about 20 species, all in the genus *Sphyraena,* found in warm seas world-wide. Though frequently found near shore, these fish are often pelagic and found far from land. All are highly piscivorous, using their great speed to cut out prey from schools or to take prey with a short rush from a lurking point.

In the western Atlantic, the barracudas are represented by four nominal species. One of these, *S. borealis,* is common in the fauna of the Mid-Atlantic Bight, while two others, *S. barracuda* and *S. guachancho,* occur as summer or fall strays. The one western Atlantic species not occurring in our region, *S. picudilla,* is separable from *S. borealis* only on the basis of a few morphometric characters, with these forms intergrading somewhat but still possibly separate in southern Florida (Houde, 1972). There is the possibility that there are, in fact, only three western Atlantic species and all three occur within this range. If this is the case, *S. borealis* is the older name and would be retained.

Sphyraena barracuda (Walbaum), Great barracuda

ADULTS

D. V–I, 7 [20]–10 (usually 8 or 9 [1,2,3,4,19,23]); A. I [1,2,3,16,19]–II,[13,14,20,23] 7 [1]–9; [19] C. 8+7 unbranched rays; [2] P. 11–12; [1,2,3] V. I, 5; [2] scales 75–85,[4,19,25] (rarely, over 90), 8–10 rows between lateral line and base of the soft dorsal; [23] vertebrae total 24,[20,22,27] 12+12; [22] gill rakers obsolescent; [1,2,3] teeth canine, 6–9 pairs of palatine canines.[3]

Body proportions expressed as percent SL: Body depth, 12.1 [3]–15.8; [1] head 27.8–40.5 [3] (decreasing with size [1]); eye 3.3–6.7 (decreasing with size); snout 14.3–17.5 (decreasing with size); depth of caudal peduncle 6.6–7.7.[1]

Body fusiform,[2,3] elongate, cylindrical,[14] or slightly compressed; head cuboidal behind eyes, snout conic; mouth very large, lower jaw slightly projecting; [16] gape to posterior margin of eye.[1] Scales large, cycloid.[16] Lateral line well developed, straight.[20] Origin of first dorsal fin behind origin of pelvic fins,[3] pelvic fins abdominal,[20] caudal fin with three semilunar notches giving the impression of four lobes in fin.[1,3]

Pigmentation: Body coloration variable, capable of lightening or darkening in relationship to background, on dark moonless nights, belly may become darker than dorsum; [5] back may be barred, in which case there are 18–22 cross bars which are inclined obliquely backwards; each bar may appear solid or each may be broken into two, nearly separate, ovoid blotches; [1] otherwise the back may be sea green,[11] dark green or gray [13] or blue-black [3] with sides silvery [3,11,13,23] and belly white,[1,3,11,23] or entire body may be silvery; [11] well defined, irregular inky blotches may be present, these generally confined to sides below the lateral line and above the transition to a white belly; [1,3,11,13] upper part of head and opercle usually dark, dusky or black; [1,3] median fins dark to black [1,3] with the soft dorsal, anal and caudal fins, margined in paler colors or white,[1,3,23] these margins becoming more distinct with age; [1] pectoral fins dusky with pale ventral margins [1,3] and pelvic fins white; [3] black axillary patch present.[3]

Maximum length: Said to reach a length of about 3050 mm [17] but other recent estimates of its maximum length are more conservative at 1500 mm,[3] 1676 mm,[1,13] 1830 mm,[9,12] or 2000 mm.[23] Maximum known weight is a little more than 45.4 kg [1,7,13] though one weighing 23 kg would be considered large.[11]

DISTRIBUTION AND ECOLOGY

Range: Red Sea, Indian and Pacific oceans and tropical Atlantic; in the western Atlantic from Bermuda, the West Indies, South Carolina to Brazil occasionally straying north to Massachusetts; [7,11,14] absent from the eastern Pacific [1,13] and distribution seems to be limited in part by the 20 C isotherm.[1]

Area distribution: New Jersey,[1,9,20,21] Maryland [1,10,24] and near the mouth of Chesapeake Bay.[1]

Habitat and movements: Adults—reefs, shallow flats and mangrove habitats but often pelagic over deep water.[1,18] North of Miami, Florida most often offshore and pelagic; [1] considerable movement of individuals as indicated by recapture of tagged individuals; [4] seem to move northward in the spring and southward in the fall, the spring movement coordinated with a general offshore movement; typically marine, occurring in salinities from 24.0 to 36.6 ppt [1] but recorded as low as 4.5 ppt; [26] one specimen from Puerto Rico was taken at 46 ppt [12] and in these same waters, this species is known to enter brackish water; [15] normally 23.3 C is the coldest temperature tolerated [1] but have been taken down to 18 C; [26] in northern Florida barracuda tend to avoid water above 28.3 C while in southern Florida they tolerate higher temperatures; reported to become sluggish at 30.0 C [1] but have been taken at 36 C; [26] known to occur at depths down to 61 m.[1]

Larvae—reported from surface to 800 m over waters 410–5250 m deep; 23.6–27.05 C; 34.98–36.08 ppt surface salinity.[1]

Juveniles—occur in a variety of habitats: tidepools; [1] open sandy beaches; [6] associated with detritus, floating sargassum weed, *Thalassia* or algal floats; among turtle grass and algae; [1] mangrove lined grassy habitats [4] or even near the upper tidal limit of mangrove swamps; [3] unlike the adult, there is little movement; [4] usually encountered in marine salinity waters, but may enter low salinity waters to 16.7 ppt; [1] in the St. Johns River, down to 14.5 ppt; [8] sometimes avoids 34.1 C while at other times tolerating 34.4 to 35 C.[1]

SPAWNING

Location: Probably occurs over deep water near the juncture between oceanic and coastal circulation so that eggs and larvae may be subsequently entrained in both inshore and offshore waters.[1]

Season: Spawning near Miami seems to occur between April and October with a peak in July and with possible secondary peaks in May and September; small juveniles occur in Haiti about one month before they do in Florida; [1] East African populations seem to spawn from September to May; [1,3] very small juveniles (24 mm) have been taken in North Carolina in September.[10]

Temperatures: Spawning seems to occur when water reaches 22.8–23.3 C and stops when water temperatures drop from about 28.8 to 25 C.[1]

Fecundity: A female 895 mm FL had 560,000 eggs while one about 1011 mm FL had about 670,000.[1]

EGGS

Unfertilized ripe eggs range from 0.74 to 0.81 mm.[1]

YOLK-SAC LARVAE

No information.

LARVAE

5.5–8.6 mm SL.

Dorsal fin with 3 rays visible at 5.5 mm SL, spinous dorsal fin still unformed; at 6.6 mm SL all rays present in soft dorsal fin but spinous dorsal fin still unformed; at 5.5 mm SL anal fin present only as a transparent membrane while at 6.6 mm SL all rays are formed; at 5.5 mm SL caudal fin heterocercal with the lower lobe longer while at 6.6 mm SL it is nearly symmetrical; pectoral fin pediculate and membranous at 5.5 mm SL and still pediculate at 6.6 mm SL; pelvic fins absent at 6.6 mm

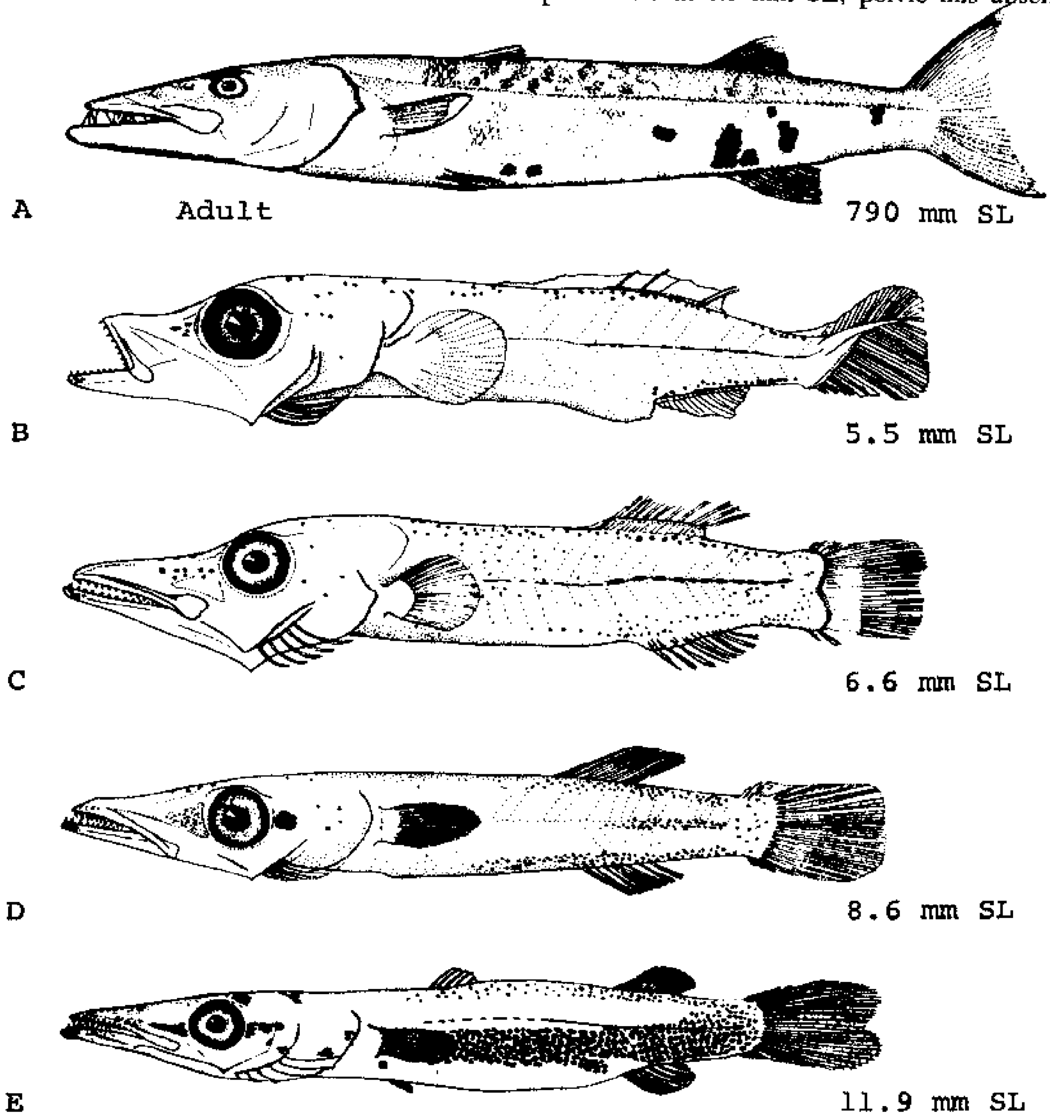


Fig. 15. *Sphyraena barracuda,* Great barracuda. A. Adult, 790 mm SL. B. Larva, fin rays forming, notochord flexing, 5.5 mm SL. C. Larva, jaws elongating, dorsal finfold present only as trace, 6.6 mm SL. D. Larva, postocular portion of future lateral band formed, pelvic bud not yet formed, 8.6 mm SL. E. Juvenile, spinous dorsal formed, pelvic fin formed, lateral pigment band formed, 11.9 mm SL. *(A-E, de Sylva, D. P., 1963: figs. 7D, 6.)*

SL. Total myomeres 24, 14 preanal and 10 postanal; branchiostegals well developed at 5.5 mm SL.[1]

At 5.5 mm SL eye is 24% HL, snout 12.2% SL, head 36.6% SL, body depth 15.4% SL; at 6.6 mm SL the eye is 19.3% HL and snout 18.1% SL.[1]

Snout profile curved at 5.5 mm SL but nearly straight at 6.6 mm SL; maxillaries well developed at 6.6 mm; teeth well developed at 5.5 mm SL; flexion of the notochord nearly complete at 6.6 mm SL.[1]

Pigmentation: At 5.5 mm SL scattered melanophores on preorbital region and on tip of lower jaw as well as scattered dots on the nape which extend down to upper margin of the opercular series; scattered pigmentation is seen along dorsal surface and as a series of concentrated melanophores along anal fin base.

At 6.6 mm SL preorbital pigmentation is more distinct; body pigmentation increased but still concentrated along middorsal and midventral lines and a band of melanophores occurs as a broken line along posterior part of trunk along the lateral line.[1]

At 8.6 mm SL preorbital pigmentation assumes a definitely triangular shape and a dusky, obscure patch appears along the hyomandibular-opercular area; trunk pigmentation concentrated posteriorly along the lateral line and at the middorsal and midventral sections.[1]

JUVENILES

Larger than 11.9 mm SL.

Gape extends to anterior margin of eye; front teeth become canines by 23.7 mm SL; caudal fin becomes bifurcated by 11.9 mm SL; scales first appear on caudal peduncle at 25 mm; keeled scales first noted on caudal peduncle of juveniles of 50–70 mm SL; at 28–30.1 mm FL no scales present below the spinous dorsal; at 30.2–31.0 mm FL scales might or might not be present there; at 31.8–38.0 mm FL scales are always developed below the spinous dorsal.[1]

Pigmentation: At 11.9 mm SL darker pigmentation on snout, an incipient band of pigment along head from snout to preopercles and small, indistinct blotches formed on lower sides of the body.[1]

At 17.2 mm SL melanophores more diffuse along the cephalic region, coalescing along snout to become confluent with lateral pigmentation of trunk, suggesting a diffuse, longitudinal band.[1]

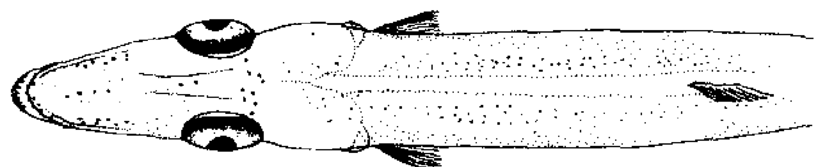
At 23.7 mm SL lateral band of melanophores begins breaking up anteriorly.[1]

In the range 23.7 mm SL to 213 mm SL pigmentation pattern changes from a partially broken longitudinal band through a series of H-shaped blotches; horizontal connections are eventually lost so that the blotches form wavy oblique bands along upper sides and back; soft dorsal, anal and caudal fin lobes show white tips and pectoral fins are pale to dusky; pelvic fins with central rays blackish, white margins present; [1] capable of losing most dark markings when over light backgrounds; over white sand only median fin tips (except that of anal fin) are dark.[6]

GROWTH

Juveniles with a mean length of less than 40 mm SL in April while in December mean is more than 120 mm SL.[1]

Based on scale annuli: Age I, mean length less than 400 mm FL; Age II, mean length more than 500 mm FL; Age III, mean length about 600 mm FL; Age IV, mean length about 700 mm FL; Age V, mean length between



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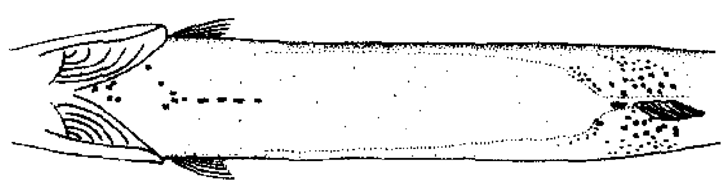

B

Fig. 16. *Sphyraena barracuda*, Great barracuda. A. Dorsal view of larva, no prominent pigment patterns along dorsal aspect. B. Ventral view of larva, mid-ventral line of pigment confined to anterior portion of belly and throat, scattered melanophores about anal fin. (*A-B, de Sylva, D. P., 1963: figs. 5B, 5E.*)

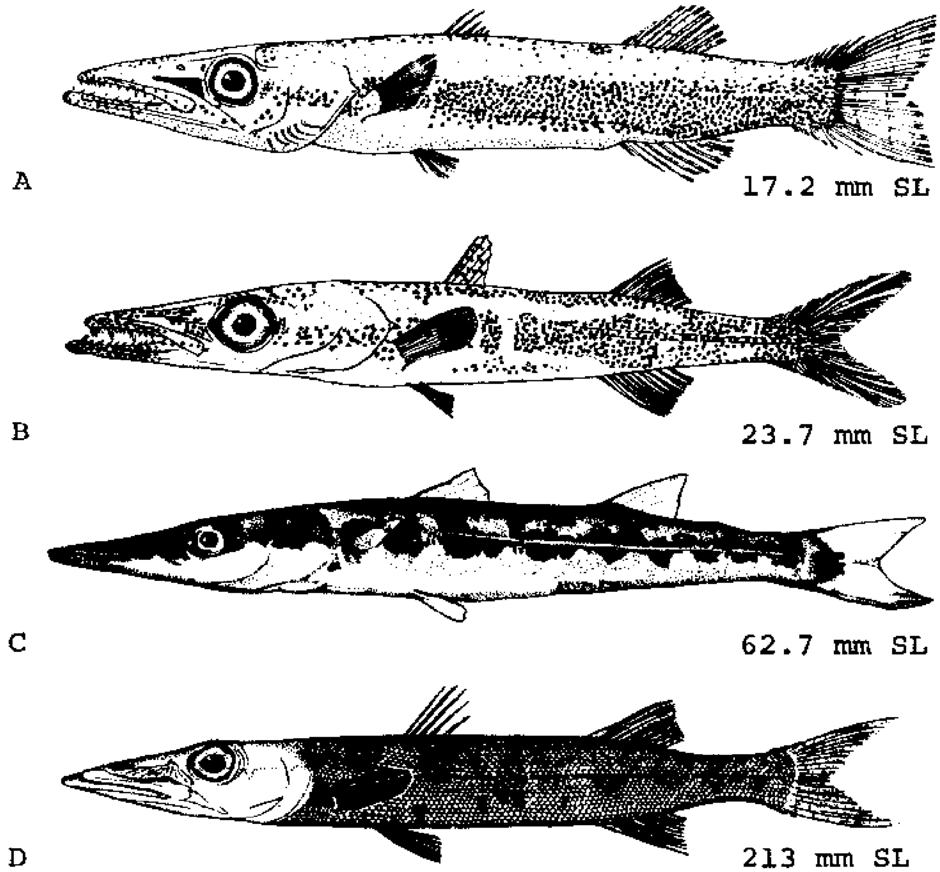

Fig. 17. ***Sphyraena barracuda***, Great barracuda. A. Juvenile, pigment becoming scattered on head, 17.2 mm SL. B. Juvenile, lateral pigment band breaking up anteriorly, 23.7 mm SL. C. Juvenile, blotched juvenile pigment pattern, 62.7 mm SL. D. Juvenile, beginning of adult color pattern, 213 mm SL. (*A-D, de Sylva, D. P., 1963: figs. 7A, 7B, 4B, 7C, 1 fig. 4B delineated by Donna Jean Davis.*)

700 and 800 mm FL; Age VI, mean length less than 800 mm FL; Age VII, mean length more than 800 mm FL; Age VIII, mean length about 900 mm FL.[1]

Based on recapture of large juveniles or small adults, there was an average growth of 5.6 mm SL/month in Florida waters.[4]

AGE AND SIZE AT MATURITY

Males mature at 2 years and around 460 mm FL in Florida while females mature at 3 or 4 years and at about 660 mm FL; in Ceylon maturity is reached at 350–410 mm SL.[1]

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Sphyraena borealis DeKay, Northern sennet

ADULTS

D. V[14,17] to VI–I, 8[15]–9;[14,15,17] A. I[14,17] or II, 8[15]–9;[14,15,17] C. 9+9+8+9;[18] V. I, 5;[17] lateral line scales 115[2,17]–130[17] (132–138[15]) (118–135[7]); vertebrae 24,[17,28] 12+12;[18] gill rakers, none;[15,17] teeth, about 40 premaxillary teeth which are smaller than the maxillary teeth, maxillary with rear teeth directed backward, anterior palatine teeth larger than maxillary teeth, palatine teeth about 10 in a series.[14,17]

Proportions in percent of HL: Eye 16.7,[14] 17.5–18.9;[15] body depth about 50;[14] snout 41.7–45.4; maxillary length 37.0–40.0.

Body elongate, slender,[15] subterete;[17] head low with a conical snout;[15,17] lower jaw with a fleshy tip;[14,17] maxillary not reaching a vertical with the anterior of the eye by about one-half the width of the orbit.[14,17] Scales moderate size.[17] Origin of the first dorsal fin above or slightly in advance of the origin of the pelvic fins; tip of adpressed pectoral fin falls short of origin of pelvic fin.[7,14]

Pigmentation: Olivaceous[10,14,17] to grayish brown[15] above, silvery below.[10,14,15,17] A dark longitudinal stripe sometimes present, this often broken up into blotches along the lateral line to the caudal base; upper surface of head and snout black; dorsal and caudal fins dusky and other fins pale.[15]

Maximum size: To 457 mm[12,15] but usually less than 305 mm.[10,13,27]

DISTRIBUTION AND ECOLOGY

Range: North to Woods Hole[4] and Martha's Vineyard[4,6,8] with one record on the north side of Cape Cod;[10] south Florida tip and throughout the Gulf of Mexico and along the Central American coast to Panama, also questionably recorded from Bermuda, Santo Domingo and Rio de Janeiro.[7]

Area distribution: New Jersey,[2,5,11,19] Delaware,[9] Maryland Atlantic coast[14] and Virginia;[3] within Chesapeake Bay, confined to the lower part.[16]

Habitat and movements: Adults—schooling. Found inshore at Woods Hole from July to December but adults rare throughout this period. Move out or die off after first snowfall.[4]

Larvae—pelagic.[1]

Juveniles—schooling.[4] Common inshore at Woods Hole from July to December;[4,8] available to beach seining in Florida.[1]

SPAWNING

Probably offshore as the eggs taken in December by Houde were from the Florida Current about 8 km east of Miami. Eggs were collected at 23.6 C. Larvae and juveniles were collected in January.[1]

EGGS

Pelagic, 1.22–1.24 mm diameter; yolk transparent and vaguely segmented. Oil droplet single and 0.27–0.29 mm in diameter; oil droplet clear yellow; perivitelline space narrow.[1]

EGG DEVELOPMENT

Incubation time unknown but eggs hatched at about 20 hours after collection at 24 C.[1]

YOLK-SAC LARVAE

2.6–4.0 mm SL.

24 myomeres through development, 14 preanal, 10 postanal; 24 vertebrae.[1]

Jaws not elongate at hatching but elongate shortly after yolk sac absorption; yolk mass large and nearly spherical at hatching, absorbed by fourth day post-hatching; oil globule, in anterior end of yolk mass, is also absorbed by fourth day post-hatching; mouth develops at 4.0 mm SL (about 3 days post-hatching). Pectoral fin well developed but without discernible rays by 3.8 mm; gut moderately long at hatching.[1]

Pigmentation: Xanthophores common and both silver iridiophores and blue chromatophores present on living specimens; both melanophores and xanthophores present at hatching; small melanophores distributed in a dorsolateral and ventrolateral row on each side of the larva, the two rows converge as a single row above the yolk sac and run anterior as a single row to the posterior cephalic region, joining a series of melanophores located over the hindbrain. Other melanophores present on anterior half of the oil globule and near posterior of the yolk sac. One to two days post-hatching (about 3.8 mm SL), melanophores become larger and more numerous; those located in the lateral rows and on cephalic region become stellate; more numerous on yolk sac; two small melanophores appear near developing mouth; a series of two to six small contracted melanophores noted near tip of notochord. Eye becomes pigmented at 2 days post-hatching. As larvae develop, both melanophores and

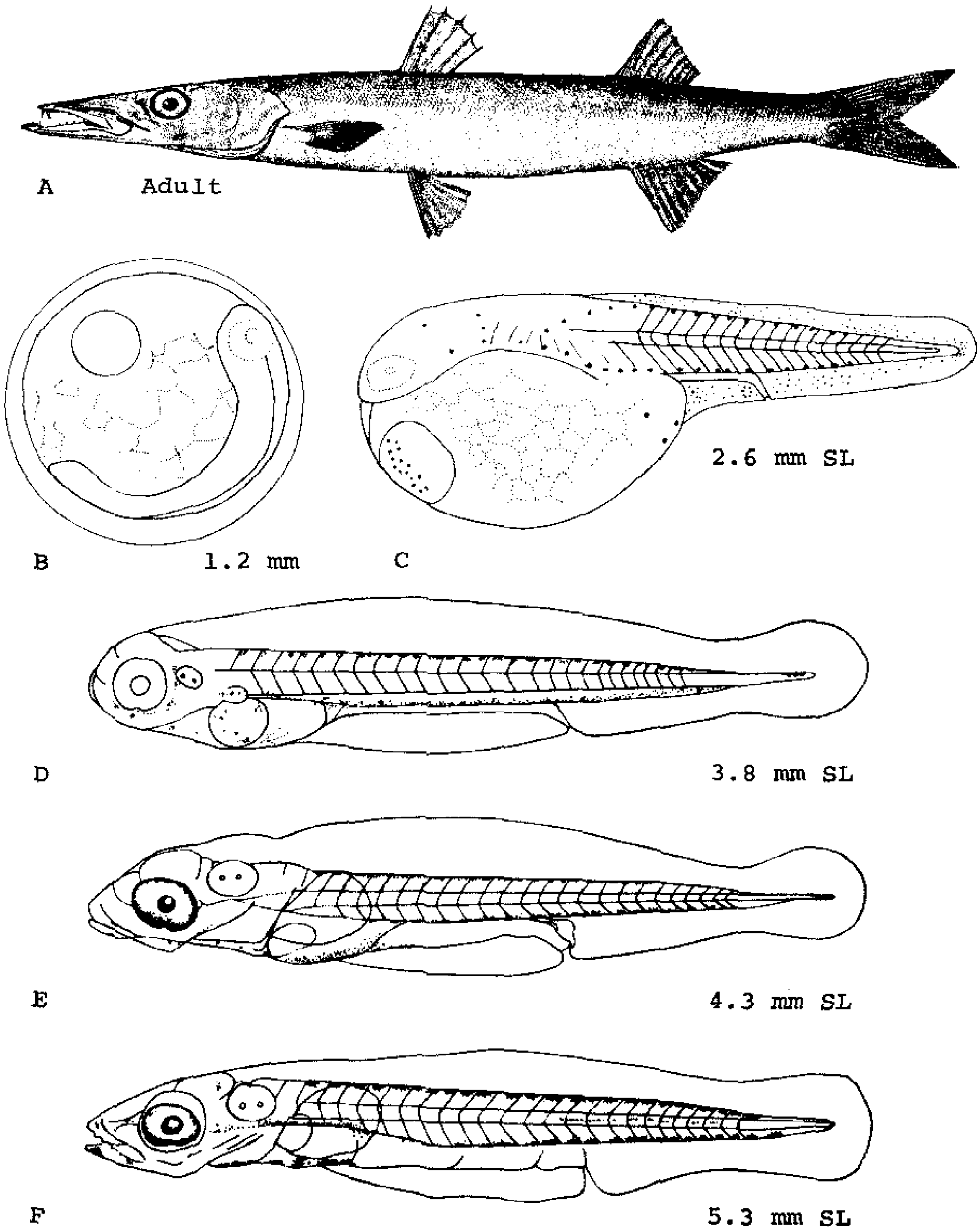

Fig. 18. *Sphyraena borealis*, Northern sennet. A. Adult, length unknown. B. Egg, diameter about 1.2 mm. C. Newly hatched yolk-sac larva, 2.6 mm SL. Dots in finfold are inclusions, not pigment. D. Yolk-sac larva, 3.8 mm SL. E. Late yolk-sac larva, 4.3 mm SL. F. Larva, 5.3 mm SL. (*A, Goode, G. B., 1884: pl. 178. B-E, Houde, E. D., 1972: figs. 1, 2A–2C. F, de Sylva, D. P., 1963: fig. 4, delineated by Tamiko Karr.*)

xanthophores become more numerous; xanthophores distributed over much of body and consist of elongate yellow cells forming a loose network on the body. In life, larvae appear green because of presence of both yellow and black pigments. Blue iridiophores on hindgut and some iridescent pigment on eyes also present.[1]

LARVAE

4.0–13.5 mm.

Second dorsal fin with 8 rays at 9.0 mm SL, 9 at 9.4 mm SL, 10 at 10.9 mm SL; first dorsal fin with 3 spines at 10.9 mm SL, 5 at 11.3 mm SL, all specimens above 12.7 mm SL have 5; anal fin with 8 rays at 9.0 mm SL, 9 at 9.4 mm SL, 10 at 10.9 mm SL, 10 or 11 in all specimens above 10.9 mm SL; caudal fin with 7 rays at 7.4 mm SL, 16 at 9.0 mm SL, 17 at 10.9 mm SL; pectoral fin with 6 or 8 rays at 11.3 mm SL, 12 at 13.7 mm SL; pelvic fins with 5 rays at 11.3 mm SL, 6 at 14.4 mm SL. Branchiostegals 6 at 7.4 mm SL, 7 at 9.1 mm SL. Fleshy tip of lower jaw begins development at 5.0 mm SL.[1]

Head changes from 13% SL in a yolk-sac larva to 33% SL in a 9 mm larva; snout 12% SL in 9 mm larva. Eye about 7% SL.[1]

Accessory caudal rays developing at 10.9 mm SL. Teeth first appear on premaxillary at 5.3 mm SL (4 teeth); bluntly conical at first becoming more canine-like by 7.0 mm SL; teeth developed on lower jaw and developing on palatine by 7.4 mm SL; palatine teeth larger than most premaxillary teeth by 12.0 mm SL; lower jaw teeth 11 at 9.4 mm SL to 15 at 12.1 mm SL; palatine teeth 6 at 9.4 mm SL.[1]

Ossification of axial skeleton begins at head and proceeds posteriorad; at 7.4 mm SL nearly complete skeletal development of head but little development posteriorly, vertebrae restricted to incomplete neural and haemal arches; centra formed at 9.1 mm SL, vertebral formation complete at 10.9 mm SL. At 7.4 mm SL only an opaque area in dorsal finfold representing the second dorsal fin, rays begin development at 9.0 mm SL, with complete complement of rays at 10.9 mm SL; at 7.4 mm SL only an opaque area in ventral finfold representing the anal fin rays developing at 9.0 mm SL, developing posteriormost first, 9 rays present at 9.4 mm SL and complete development at 10.9 mm SL; hypurals and some caudal rays present at 7.4 mm SL, all caudal elements beginning to develop at 10.9 mm SL and easily recognizable by 12.1 mm SL; last three vertebrae, counting urostyle, contribute to support the caudal fin; both neural and haemal spines of the antepenultimate vertebra (22nd) supporting accessory rays of the caudal fin as is the haemal spine of the penultimate (23rd); 6 hypurals formed near posteroventral surface of the urostylar vertebra; 3 epurals and 2 pairs of uroneurals; 17 principal caudal rays supported by the hypurals. Finfold prominent in newly hatched, appearing granular, inclusions present up to 9.5 mm SL; remnants of finfold persist until 12.5 mm SL. Notochord starts flexure at 7.4 mm.[1]

Pigmentation: By 7 days post-hatching (about 5.3 mm SL) stellate melanophores appear over the brain, on the tip of the upper law, lower jaw, angle of the jaw, ventral margin of the opercular region and over the foregut. Each dorsolateral row of stellate melanophores well developed while the ventrolateral rows condensed into a single ventromedial row posterior to the anus. A midlateral series of melanophores develops posterior to the anus.[1]

At 9 days post-hatching (about 7.4 mm SL) pigmentation more intense; about 5 melanophores present on the developing caudal fin; the fleshy tip of the lower jaw darkly pigmented at this stage; the extent and intensity of pigmentation increase with age. No changes in pattern noted except for development of a line of pigment bisecting the eye and a migration of melanophores from the tip of the developing urostyle to the ventral margin of the hypural plate.[1]

At 20–22 days post-hatching (about 12.5–14.5 mm) the juvenile pattern of dorsal and lateral blocks of pigment begin to appear. Stellate melanophores also developed in the second dorsal and anal fins of individuals of this size.[1]

JUVENILES

13.5 mm and larger.[1]

Eye 5.3% SL at 150 mm SL, 4.9% SL at 200–250 mm SL. 4.7% at 300 mm SL, body depth 12.0–13.0% SL.[7]

Keeled scales on caudal peduncle of specimens as small as 14.5 mm SL.[1]

Pigmentation: Pigment pattern of dusky blotches along the back and along the lateral line;[10] preorbital pigmentation diffuse, scattered; caudal fin base without pigmentation; middorsal line straddled by relatively large distinct melanophores arranged serially from a point above the pectoral fin origin to the end of the soft dorsal fin base; melanophores at base of soft dorsal and anal fins, if present, small and diffuse; a few large melanophores on occipital region; tip of snout generally heavily pigmented.[7]

GROWTH

2.6 mm SL at hatching, 5.5 mm SL at 7 days, 11 mm SL at 14 days, 13.5 mm SL at 21 days.[10]

AGE AND SIZE AT MATURITY

No information.

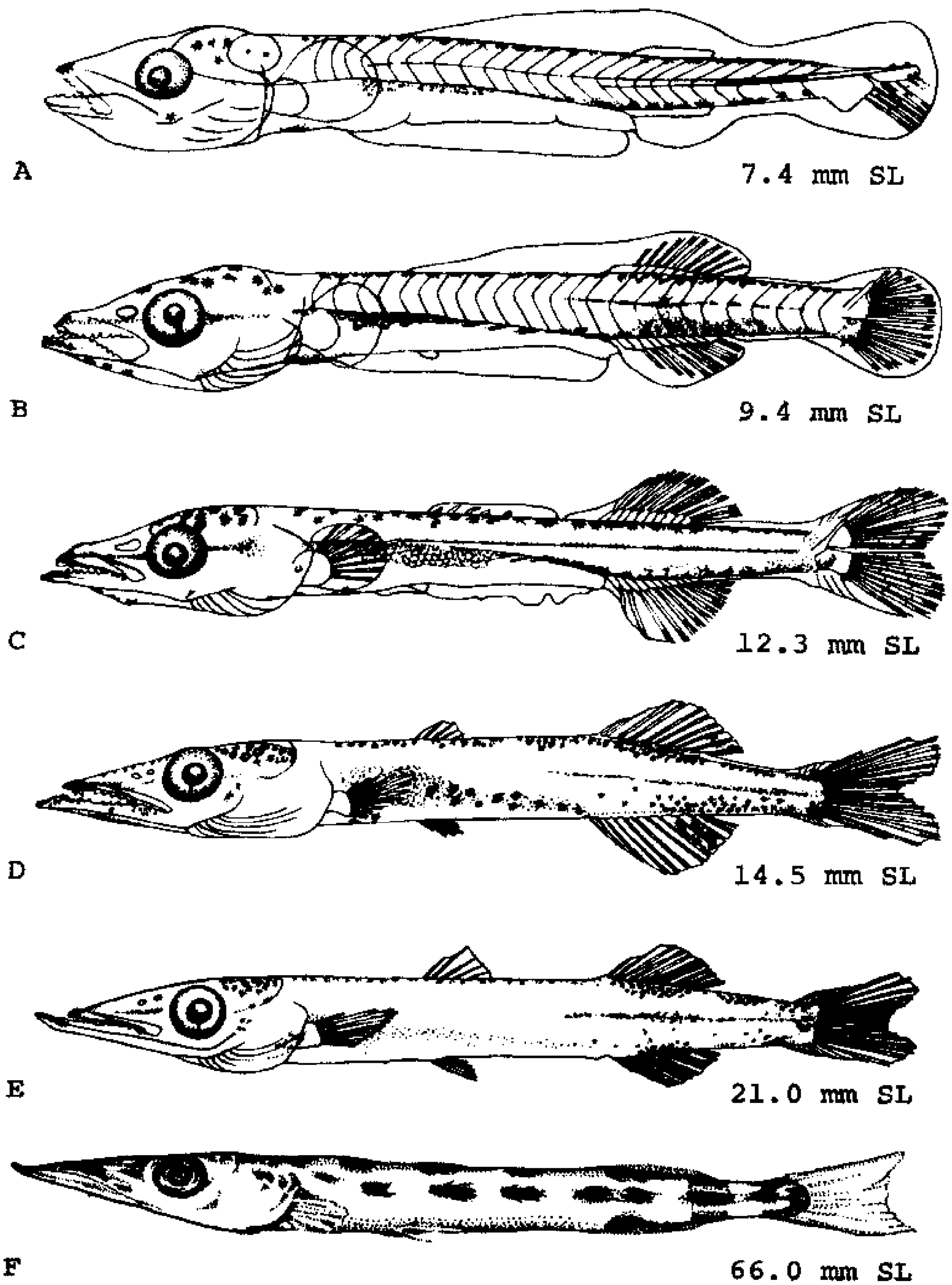

Fig. 19. *Sphyraena borealis,* Northern sennet. A. Larva, caudal rays forming, soft dorsal and anal fin outlines forming, 7.4 mm SL. B. Larva, fin rays forming, notochord flexed, preanal finfold prominent, pelvic buds formed, 9.4 mm SL. C. Larva, fin becoming forked, dorsal spines forming, 12.3 mm SL. D. Larva, pelvic fins formed, preanal finfold completely gone, 14.5 mm SL. E. Juvenile, juvenile pigment pattern not yet formed, 21.0 mm SL. F. Juvenile, juvenile pigment pattern well formed, 66.0 mm SL. (*A-E, Houde, E. D., 1972: figs. 2D, 3. F, de Sylva, D. P., 1963: fig. 4A.*)

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Sphyraena guachancho Cuvier, Guaguanche

ADULTS

D. V, I, 9;[2] A. I, 8[2,5] (7–8[3]) or II, 8;[17] V. I, 5;[5] C. 10+9+8+9;[17] scales, 108–122,[3] 120–130;[4,5] vertebrae 12+12;[17] gill rakers obsolete; teeth large, lance-shaped in jaws and on palatine,[2] premaxillary teeth 35–40, about 10 large teeth in lower jaw.[5]

Proportions expressed as percent HL or TL: Body depth 50 HL; eye 18.2 HL; first predorsal length 42.9 TL.[5]

Body very elongate, nearly cylindrical; mouth large, a little oblique, lower jaw projecting, gape reaching anterior edge of eye; scales small; first dorsal fin origin behind base of pectorals, second dorsal fin origin in advance of anal origin, caudal fin forked.[2]

Pigmentation: Dorsum grayish,[1] bluish gray[2] or olivaceous,[8,12] silvery on sides and venter,[1,2,9,12] faint yellow or golden stripe in life;[12] upper part of head dark gray or blackish;[1] some specimens with irregular black blotches;[2,9] margins of anal and pelvic fins and tips of middle caudal rays black;[12] dorsal fins dusky and pectoral fins pale.[2]

Maximum length: To 1 m[1] but usually to 610 mm.[2,10,11]

DISTRIBUTION AND ECOLOGY

Range: Woods Hole, Massachusetts,[2,7,9,10,11,12] to Brazil[10] including the Gulf of Mexico and the Caribbean Sea,[2,10] drifting to the eastern Atlantic.[2,10,12]

Area distribution: Lower Chesapeake Bay in Virginia.[2,6,9]

Habitat and movements: Adults—turbid water along silty shores,[3] along shorelines in shallow water or close to the bottom in clear bays and harbors.[12]

Larvae—no information.

Juveniles—turtle grass (*Thalassia testudineum*) beds, open, silty bottoms in shallow bays (FDM).

SPAWNING

No information.

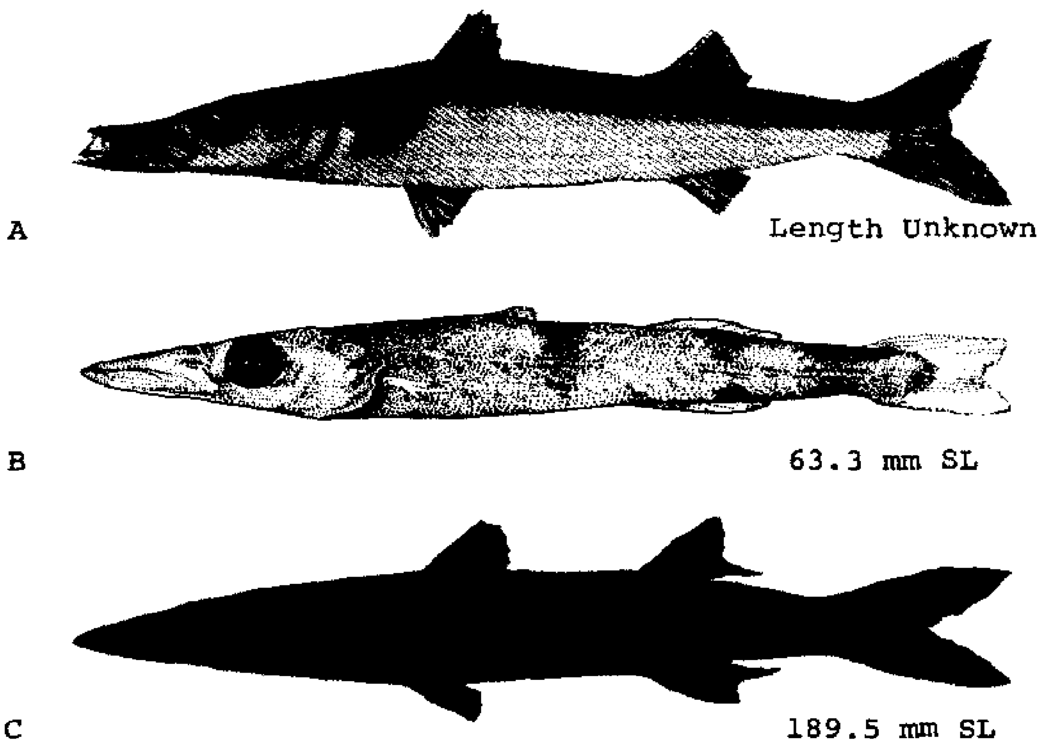

Fig. 20. *Sphyraena guachancho*, Guaguanche. A. Adult, length unstated. B. Juvenile, with juvenile color pattern, 63.3 mm SL. C. Juvenile, with adult color pattern, 189.5 mm SL. (*A, Pew, P., 1954: fig. 20. B, de Sylva, D. P., 1963: fig. 4C. C, Böhlke, J. E., and C. C. G. Chaplin, 1968: 201. Copyright © Academy of Natural Sciences of Philadelphia, used with permission of authors and publisher.*)

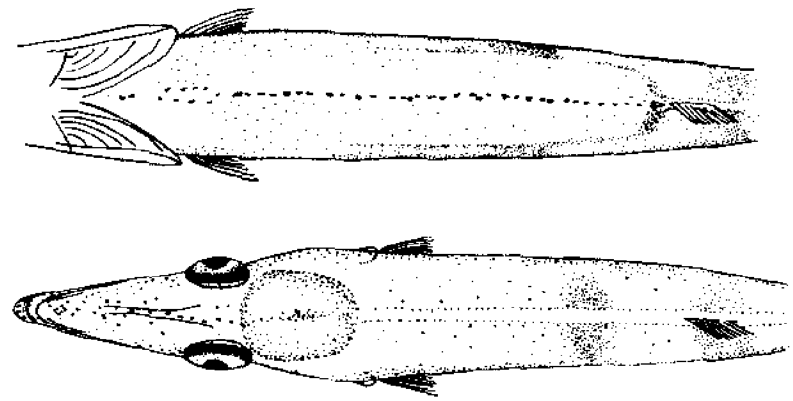

Fig. 21. Sphyraena guachancho, Guaguanche. A. Larva, ventral aspect showing mid-ventral pigment pattern. B. Larva, dorsal aspect showing dorsal portions of transverse bands. *(A-B, de Sylva, D. P., 1963: figs. 5C, 5F.)*

EGGS

No information, presumably pelagic since the eggs of *S. borealis,*[13] *S. argentea,*[14,16] and *S. pinguis*[15] are known to be pelagic.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

5.5–11.9 mm SL. Presumed to be larvae (FDM).

Mid-ventral row of melanophores extending posteriorad from isthmus to vent; lower jaw tip heavily pigmented. Faint pigmentation only on either side of mid-dorsal line, melanophores at bases of soft dorsal and anal fins diffuse; two hourglass-shaped crossbands on sides in larger specimens: the first begins about two-thirds of the distance between pectoral fin origin and anal fin origin; the second commences just posterior to anal fin base. Preorbital pigmentation generally not distinctive.[10]

JUVENILES

Descriptions based on specimens 12.3–160 mm.

Scales nearly complete in number by 12.3–130 mm SL. Maxillaries strongly arched in specimens 5.5–130 mm SL. Lateral line raised and broad. Scales on the lateral line noticeably larger than others in specimens 12.3–130 mm.[10]

Pigmentation: Upper surface of lower jaw blackish; tips of middle caudal rays usually blackish with center rays darkest, stippled. Three hourglass-shaped bands on body: first beginning at about last spine of first dorsal fin and extending posteriad about one-third of the interdorsal distance; second extends below the base of the second dorsal to the anal base with the narrowest point at about the lateral line; third about halfway between the second band and the caudal base.[10]

At 130–160 mm SL may have three encircling bands on the posterior portion of the trunk.[1,10,12] Color silvery to olive with a faint yellow to golden longitudinal band in life; margins of pelvic and anal fins black, tip of middle caudal rays black.[10]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Mugil cephalus
Mugil curema

mullets
Mugilidae

FAMILY MUGILIDAE

The mugilids, or mullets, are a family of generally similar fishes distributed in coastal waters of midtemperate to tropical regions of the world. Although apparently confined to shallow water for feeding, as a group they seem to be highly successful. Most species live in lagoons and estuaries, some entering rivers and lakes, while a few inhabit freshwater exclusively, or almost exclusively. Many are among the most euryhaline fishes known, moving freely from fresh water to salinities far in excess of normal sea water. Because they form large schools in accessible areas and because of their great biomass, most of the larger species have considerable commercial significance.

The family is characterized by conical heads and subcylindrical bodies only slightly compressed anteriorly; subabdominal pelvic fins; 16 pectoral rays; one spine plus five rays in the pelvic fins; usually four spines in the first dorsal fin, which is well separated from the second dorsal fin; weakly ctenoid or cycloid scales; little variation from a vertebral count of 24; and pelvic bones connected to the postcleithra by a ligament (Thomson, 1966).

According to Thomson's (1966) review, the Indo-Pacific region has 10 genera and 49 species of mullets, the eastern Pacific three genera and five species, the western Atlantic two genera and seven species, the northeastern Atlantic two genera and six species, and the southeastern Atlantic three genera and nine species. In every region mentioned one species is the ubiquitous *Mugil cephalus* Linnaeus. It and the slightly less abundant and wide-ranging *M. curema* Valenciennes are the only mullets in the Mid-Atlantic Bight.

Both local mullet species are strongly and characteristically migratory in certain seasons. Details of their movements are partly known only, but they probably spawn at sea well south of the mid-Atlantic states, utilizing the western edge of the Gulf Stream to transport and nourish larvae, and put the prejuvenile stage within active migration range of the middle and northeastern Atlantic coastline. Earll (1887) described the general pattern of annual migration for stages larger than prejuveniles. Briefly, each year's northward dispersal is shorter than that of the previous year for each individual, and adults three or more years old are seldom seen in latitudes above North Carolina. Spawning localities here and elsewhere in the world have remained controversial for a century. The scattered solid evidence is cited in the species accounts below; a basically catadromous pattern is indicated, on a smaller scale than that shown by *Anguilla rostrata,* and differing in features such as yearly migration and less penetration of fresh water, at least in the north (Moore, 1974).

Kristensen (1963) has shown that prejuvenile mullets are attracted to coastal water by some factor present in the water itself. This factor is independent of temperature or salinity and passes through paper filters but is removable by filtering with activated charcoal. Seasonal entry of coastal water by multitudes of prejuvenile mullets in surface-swimming schools has stimulated widespread interest, since at that stage they can easily be collected and stocked in rearing ponds. World literature on season of entry is now extensive and permits interesting comparisons (see Table 1 under *M. cephalus*). For example, the comprehensive Egyptian data of el-Zarka and Kamel (1967), when compared with that from other areas, raises at least the possibility that two separate breeding stocks of nominal *M. cephalus* coexist there, perhaps reflecting a mixing of Mediterranean and Red Sea stocks introduced via the Suez Canal.

Some descriptions of reproduction and life history stages have been omitted from the species accounts, perhaps unjustifiably. The species identification in the observations by Yang and Kim (1962) was questioned by its own authors and others. Doubts were raised about the Indian material described by Nair (1957) and by Kuthalingam (1959, 1966) by disparities between them such as placement of the oil globule, and by unexpected shared features including presence of the eggs inside estuaries, and a hatching length of 1.1 mm TL versus more than 2.0 mm TL elsewhere. After comparing all the literature obtainable, the author suspects that considerable variability exists in the world-wide population of *M. cephalus*, as presently recognized, and that additional studies are warranted to determine the real extent of genetic exchange between local subunits. To maintain usefulness of this review if future species distinctions are made, some indication of the region from which information was derived appears in parentheses after regionally variable features and in figure legends each time where stages from different regions are represented.

Mugil cephalus Linnaeus, Striped mullet

ADULTS

D. IV-I 7–8 (mode 8); A. III, 8 [4,28,80,159] (rarely II, 8 [67] or III, 6–7 [4,83,84]); P. 14–18 (mode 16); [4,28,159] V. I, 5; [159] C. 28–30 (7–8 + 7 + 7 + 7–8) [151] smallest procurrent rays visible only with dissection,[119] thus count often given as 18–20; [4,28,159] vertebrae 11 + 13 [41] or 12 + 12; [150] first interneural bifurcate above seventh vertebra; [53] lateral line scales 37–43 [4,28,77,159] (rarely 44 [77]); predorsal scales 23–26; transverse scale rows 13–15; cheek scale rows 3–4; [100] gill arches 4 on each side; [112] gill rakers 24–36 + 50–76, number increasing with size; [105] primary teeth uniserial, simple, 57–101 in upper jaw, 97–149 in lower jaw; secondary teeth in bands, bicuspid, numerous, their number increasing with size; [34] no teeth on vomer or palatines; [45] pyloric caeca 2.[41,53,90]

Means for 2 samples of 25 each as % SL: Head length 25.4–27.7; maxillary 7.0; interorbital width 9.3–10.4; greatest body depth 25.4–26.0; first predorsal 50.8–57.1, second predorsal 74.6, preanal 73.0–73.5, prepelvic 39.4–39.5; first dorsal base 12.8–13.3, second dorsal base 10.6; second dorsal height 14.3–14.4; anal fin height 15.0–15.5; pectoral length 17.3–17.6, pelvic length 15.2–15.3 (Florida).[4]

Body robust,[119] moderately elongate, compressed; [112] lower profile strongly curved from snout to caudal peduncle, upper profile less curved,[80] but arched slightly from snout to first dorsal fin origin; [159] body oval in cross section; [41] caudal peduncle rather strongly compressed. Head massive, somewhat broader than deep; [105] interorbital flat,[103,104] short,[112] and broad, its width more than twice eye diameter; [159] snout shorter than eye,[28] blunt or rounded anteriorly with a strong taper in dorsal view; [104,159] some scales on top of head slightly enlarged; [104] anterior and posterior nostrils widely separated; [45,55] preorbital weakly serrate.[28,159] Mouth moderate, oblique; [110] jaws weak; [112] lower jaw included; [105] maxillary hidden when jaws closed,[28,153] its posterior end moving forward when mouth opened; [41] lower lip with a thin edge directed horizontally forward or nearly so; [65] mandibular junction nearly a right angle but becoming more obtuse with age, notched,[120,159] with a feebly double symphyseal knob.[28] Gape somewhat broader than deep.[110] Gill openings wide; gill membranes free from the isthmus; gill rakers numerous, long, slender, and close-set; [104,110,112] pseudobranchiae large.[112] A prominent adipose eyelid almost obscuring eye, covering preorbital anteriorly and extending almost twice as far posteriorly, leaving a narrow slit over pupil.[28,159] Scales moderate,[110] cycloid or feebly ctenoid,[84,119] their posterior borders membranous, crenate [110] with a central emargination; some scales with a single,[8] somewhat oblique mucous groove.[110] Lateral line inconspicuous.[83] Pectoral fins above midline, at level of eye; originating about length of head behind eye; tips pointed, not reaching first dorsal origin; a distinctly enlarged scale in pectoral axil; pelvic fins subabdominal; origin of first dorsal fin over pelvics; first dorsal spine longest, others graduated, last spine about half as long as first; origin of second dorsal fin slightly behind anal origin; upper margin concave, longest ray nearly same length as longest spine of first dorsal; anal fin about same size and shape as second dorsal but margin less concave; caudal fin deeply forked; longest rays nearly as long as head, shortest about half as long.[41,93,104,105,159] Fine scales extending onto caudal fin and some on anterior rays of second dorsal and anal.[39,101,110]

Pigmentation: Color varies with habitat and salinity,[101,119] in fresh water very dark dorsally with overlay of dirty brown or bluish color, dull white ventrally; in marine waters dorsum olive green, sides silvery, venter off-white.[119] In general, dorsum grayish olive,[98] grayish blue,[98,110] grayish brown,[101] bluish brown [105] or dark blue; [80,83] shading to silver white on sides and white or pale yellow ventrally; [101,110] many brown spots on sides, organized into rows along scale centers on upper half, forming 5 [103] to 10 [104] dark longitudinal stripes on upper scale series down to about the tenth,[100,104,112,119] lower band not extending behind anal origin.[103] Sometimes a terminal caudal bar in migrating adults (RHM). Fins dusky, minutely dotted with black, except pelvics, which are a pale yellowish color; [100,119] pectoral black at base of upper rays and distally, with a narrow pale margin, inner surface almost black; margin and last few rays of anal fin pale.[105] A dark blue streak or spot in the axil of pectoral.[100,103,110] A golden ring around the iris,[73,119] this color evenly distributed (RHM).

Maximum size: Varies in different areas,[23,28,47,74] limit ca. 900 mm TL [47,101] or 914 mm TL for India [159] and Salton Sea, California.[113] Regional records include 511 mm TL in Chesapeake Bay.[67]

DISTRIBUTION AND ECOLOGY

Range: Adults world-wide along continents to approximately 42° N and 42° S [28] (46° N in Mediterranean and Black Sea), rare or absent in Philippines, East Indies [76,101] and West Indies [14] (verified FDM), not reported from the Bahamas [130] or Venezuela.[81] Island occurrences include Taiwan, Hong Kong, Hawaii, Guam, Marshall Islands [100] and islands of the Great Barrier Reef,[114] some of these (e.g., Taiwan,[31] Hong Kong [27]) populated seasonally by migrating spawners from nearby continental waters. Juveniles often collected outside the above latitudes, usually in the fall, e.g., Nova Scotia,[88] Maine,[57] New Hampshire.[66,109]

Area distribution: Immature individuals common in Chincoteague and Sinepuxent Bays on the Virginia-Maryland coast,[35] and in Chesapeake Bay, particularly on the western shore, also common in bays near Ocean City, Maryland [13] and along Delaware and New Jersey coasts.[132]

Habitat and movements: Adults—coastal waters generally from freshwater to hypersaline lagoons. Apparently restricted to shallow water during a discrete "trophic (feeding) phase." Trophic phase adults typically in freshwater in Australia,[28] estuarine elsewhere but readily entering freshwater.[28,72,127] Reported to prefer muddiest water in Colorado River drainage.[120] Many adults thought to remain outside estuaries after their first spawning in South Africa; [63] shallow marine populations at Heron Island on Great Barrier Reef [114] and Shark Bay in western Australia [118] considered possible permanent *marine aggregations,*[28] *although only winter catches* reported at Heron Island.[114]

Minimum temperature 4.5 [8]–9 C,[112] maximum ca. 37 C (1 adult collected at 36 C).[14] Heated water (outfall temperature 8 C above ambient) a possible factor attracting huge numbers of adults to a Texas power plant effluent in winter.[107]

Euryhaline, salinity range 0–81 ppt; [14,50,62,65] live mullet of unspecified size at 84–86 ppt in South Africa, also deaths and emigration above 75 ppt,[62] pattern similar in hypersaline Laguna Madre of Texas.[95]

Typically near surface in marine environment; [7,44,154] deep occurrences in trawl collections mostly west African, several adults recorded between 80 and 240 m,[29] one at 329 m.[140]

Adults characteristically mobile, but migration periods interspersed with relatively sedentary trophic periods; local movements consisting largely of travel to and from tidal flats with tides [28,140] often feeding on flats at night, retreating to channels in daytime.[37] Exact timing of migrations variable from year to year, sometimes by as much as 2 months.[28] Trophic phase appears universal through late spring to summer or fall, later in subtropics and tropics. Migration onset marked by increase in size of schools, followed by movement down streams and estuaries into open marine water; males [129] and large females predominating among early migrants.[65,75] A net directional trend toward tropics present in alongshore movements of high latitude stocks; [75,90,110,132] in Florida trending also counter to prevailing direction of inshore currents.[89] In autumn spawning and/or non-spawning fish reported to move south of Cape Hatteras, North Carolina,[132] from temperate toward tropical Australia,[75] and from Sea of Azov to the Crimean coast of the Black Sea.[142] Winter movement suggested to be out of estuaries onto the continental shelf in southeastern U.S.[88] and South Africa; [62] some winter movement in and out of estuaries with weather changes indicated in North Carolina.[92]

Maximum residual displacement of tagged *M. cephalus* 563 km in Florida,[89] 740 km in Australia; [75] in the 4 year Florida study, 2.1% of recaptures traveled more than 160 km, 4.5% more than 80 km, but 90% of recaptures after 270 days were within 32 km of marking point.[89]

Larvae—generally collected with eggs from surface of Black Sea [153] but concentrated in certain offshore areas; [50,87,131] in surface-towed nets 60–80 km offshore in Gulf of Mexico; [7] from the Gulf Stream shoreward off North Carolina to Florida,[1,12] within ca. 16 km of the Israeli coast,[20] and from Japanese inshore waters outward ca. 500 km to the east [52] and 300 km to the south.[51] Classified as marine hyponeuston in the Black Sea, with principal concentrations predicted to exist at least 8–16 km offshore (to avoid beach stranding and surf damage).[126]

Temperature range 15.8–25.3 C near Japan, frequency of occurrence strongly peaked near 21 C; [52] 24.0–28.0 C in Black Sea.[50] Hawaiian laboratory survival range 16.5-27.5 C with 24.9 C optimum for first 12 days.[121]

Salinities 10.93–12.83 ppt in Sea of Azov, 16.3–18.0 ppt *in Black Sea.*[126] *Hawaiian laboratory survival reduced* below 50% at 24 and 34 ppt, good survival first 96 hours in range 26–32 ppt.[15]

Water depth at sites of larval occurrence from 9 m [20] to 1385 m.[7] Some sinking by viable eggs and larvae documented,[2,9,10,69] but citation of depth of occurrence at 200 m [121] possibly a misinterpretation of Hotta (1950).[51]

Large scale larval movement apparently consisting of drift with prevailing currents.[28] Small scale and diurnal movements observed in laboratory at 20–24 C: yolk-sac larvae below but near surface, suspended or slowly *sinking yolk uppermost, with periodic righting motions* forward and upward in a semicircle; [2,6,18,54] sinking to bottom of 70 cm vessel late day 2; concentrating at surface day 3 with greater activity,[6,9] but tending to seek low light levels (600–1400 lux); *spending third* and all succeeding nights as larvae at surface; [18] diurnal up and down movement day 6,[91] a second period of sinking starting day 8 [6] or 10–13; [9,18] subsequent sustained daytime schooling in upper half of 1.5 m deep vessel.[18]

Prejuvenile ("querimana")—stage including two habitats, early part generally considered marine and pelagic; [1,2,32,1] reaching estuarine waters by drift and/or migration, entering in dense schools and dispersing in waters 2–50 cm deep [70] from the mouths of bays into freshwater streams.[2] Minimum size at entry varies: 10 mm TL (India),[40] 11 mm TL (South Africa),[61] 12.8 mm SL (Australia),[23] 15 mm TL (Israel,[127] Egypt),[124] and 16–18 mm SL (Florida,[60] Georgia [1]); maximum sizes offshore up to 29 mm (Japan) [52] and 31 mm SL (southeastern U.S. [1,12]) reported from 63 km inland by 18 mm FL (North Carolina [138]) and 193 km inland by 28 mm SL (Colorado River, Arizona).[59] Estuarine habitat possibly variable depending on other mullet species present, e.g., open shallow water away from shore in Egypt; [125] seldom found in open water or current in Florida saltmarsh, usually in small, shallow pools, with soft mud bottoms; [60] standing water in drainage ditches in Mississippi; [43] quiet backwaters around eel-grass and other macrophytes over silty bottoms coated with algae or decomposing vegetation in Black Sea area.[70]

Minimum temperatures 6 C,[134] 5.0–9.9 C; [123,185] maximum exceeding 30 C,[70] 28.5–34.5 C.[80,187]

Fish 18 mm FL in freshwater; [183] maximum salinity at least 35–40 ppt,[157] the size class represented (but not correlated with salinity) in Sinai waters that reached 74.6 ppt [117] and Texas waters that reached 54.3 ppt; [88] smaller

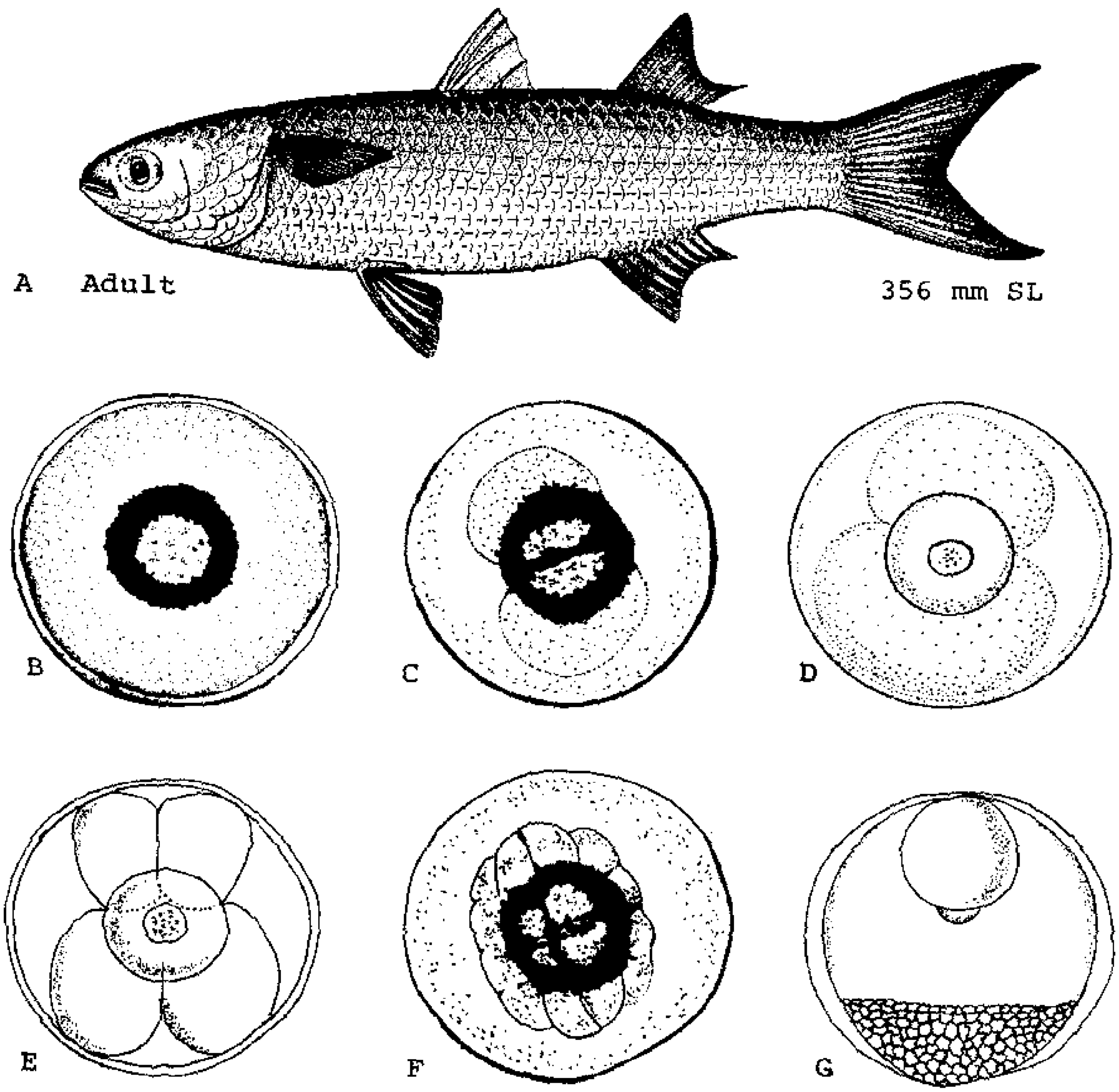

Fig. 22. *Mugil cephalus*, Striped mullet. A. Adult, 356 mm SL. B. Fertilized egg, diameter 0.91 mm (Hawaii). C. Two-cell stage, diameter 0.91 mm. D. Two-cell stage with unequal cleavage, diameter ca. 0.72 mm (Sicily). E. Four-cell stage, diameter ca. 0.72 mm. F. Sixteen-cell stage, diameter 0.93 mm. G. Morula, diameter ca. 0.72 mm. (*A, Smith, J. L. B., 1965: fig. 877, reversed. B, C, F, Kuo, C.-M.*, et al., *1973: pl. 1, figs. 1, 2, 3, delineated by Joan Ellis. D, Vialli, M., 1937: fig. 280, after Sanzo, 1936. E, G, Sanzo, L., 1936: pl. 1, redrawn by Tamiko Karr.*)

sizes apparently absent in hypersaline parts of Texas Laguna Madre,[65] survival and growth enhanced by freshening of culture water.[18,91]

Table 1 summarizes seasonal records of prejuvenile estuarine entry, with some extrapolation from indirect evidence.[2] Calendar of Table 1 rearranged to align seasons in northern and southern hemispheres; suggested peaks of occurrence indicated with the letter P; peaks ranked in amplitude using subscript numerals. Winter entry the indicated world-wide norm, shifting backward through fall to late summer with increasing latitude in Eurasia, elsewhere shifting forward through spring. Occurrence year round in Egypt, the indicated peaks based on both absolute numbers and average fry per net haul.[124]

Distance of marine dispersal indicated to be at least 100–500 km,[1,52,70,78] probably aided somewhat by currents.[147] In culture after ca. 11 mm TL schools shifting in daytime from upper to lower half of 1.5 m deep vessel, still spending nights at the surface.[18]

Juveniles—transformation from prejuvenile involves change from predaceous [20,138] to iliophagous (detritivore) feeding habits.[84,138] Habitat generally similar to that of adults: estuaries and lower freshwater zones in Australia; [28] distributed throughout river systems of Israel [128] and Florida; [22,38,145] ascending rivers for considerable distances in southern [14,127,137] and southwestern U.S.; [59,120] remaining mostly in saline waters from Chesapeake Bay northward.[14,110] Usually along sandy shores near Ocean City, Maryland, but sometimes in creeks over mud bottoms.[13]

Thermal tolerance generally similar to adults; in Hawaii lower limit 10.4–14.0 C, upper limit 29–33 C.[16] Reported to aggregate in sheltered areas before arrival of severe cold weather.[71]

Salinity tolerance similar to adults; commonly taken above 75 ppt in South Africa; juveniles, probably of this species, sighted at 84 ppt.[32]

One juvenile reported from a shrimp trawl haul at a depth of 37 m.[58]

Moving in small schools that may travel considerable distances within river and estuarine systems, also entering marine waters and traveling to other estuaries, frequently before [28,92] or after [82] the spawning migration of adults. Penetrating farther than adults toward the edges of the species range.[13,35,60,83,109]

SPAWNING

Location: Documented by eyewitness report near and at surface 60–80 km offshore in Gulf of Mexico, close to edge of continental shelf over 1385 m of water; verified by presence of eggs and larvae in plankton collections at site.[7] A wide distribution of eggs reported in Black Sea, including inshore zones,[115] but major concentrations mapped offshore,[50,86,120] these suggested to be spawned offshore [78,120] or carried offshore by wind or water currents from inshore spawning grounds.[65] In southern India eggs reported from just outside estuary,[96] their species identity questioned; and from just inside estuary,[30] their identity also questionable.[27] Reports from eastern India generally agreed that adults leave estuaries for spawning,[48,94,114,123] but very small size of enter-

TABLE 1. Season of estuarine and lagoon entry by prejuvenile *Mugil cephalus*: P_1 = primary peak, $P_{2,3}$ = additional peaks, + = present, # = occurrence sporadic.

Season	Summer		Autumn			Winter			Spring			Summer	
Month (south of equator)	J	F	M	A	M	J	J	A	S	O	N	D	
(north of equator)	J	A	S	O	N	D	J	F	M	A	M	J	
Locality													Sources
Black Sea, France	+	P_1	+	+								+	65,74,78
Italy, Corsica		+	P_1@	+	+	+							73@,91@,141
Israel	+	+	+	+	+	P_1	+	+	+				2,108,128
Sinai	+	+	+	+	+	+	P_1						117
Egypt	+	+	P_1	+	+	+	P_2	P_2	+	+	+	+	124
South Africa						+	P_1	+	+	P_2	+	P_3*	61
India						+	P_1	+	P_2	+	P_3	#	48,49,123
Hong Kong						+	+	P_1	P_2	+	P_3	#	27
Taiwan						+	P_1@	P_1@	+				18,31@
Japan					+	+	P_1	+	+	+			52,134
Hawaii								+	+	+	+	+	15
Australia								P_1	P_1				23,79
Chile			P_1	+	+	+	+	+	+	+	P_2		157
Texas					#	+	P_1	+	+	P_2*	+		36,46,64,107
Mississippi					+	+	P_1	+	+	+	+		155
Alabama					+	+	P_1	+	+	P_2	+		122
N. Florida	+			#	+	P_1	P_1	+	+	P_2	P_2	+	60,135,136,138
S. Florida				#	+	P_1	P_1	+	P_2	P_2	+	P_3@	32,42,146
Georgia					+	+	P_1	+	+	P_2	+	+	1
S. Carolina					+	+	+	P_1	+	+	P_2	+	12@,158
N. Carolina	+				+	+	+	+	P_1	+	+	P_2	84,133
Virginia									+	P_1	P_1	+	144@
Maryland										+	P_1	+	110

*Peak weak, sporadic, not present every year.
@Evidence extrapolated from literature clues, larval occurrence, etc.

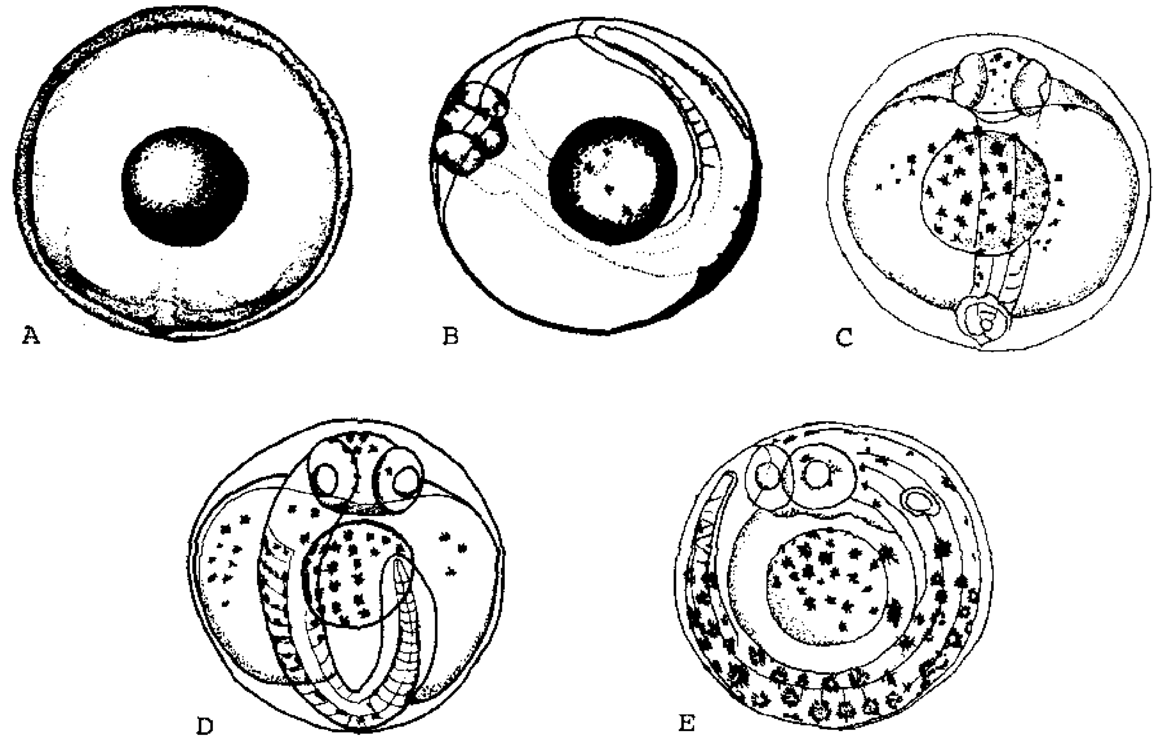

Fig. 23. *Mugil cephalus*, Striped mullet. A. Late neurula, diameter 0.93 mm. B. Embryo, note pigment on oil globule, diameter ca. 0.93 mm. C-E. Late embryos, diameters ca. 0.72 mm. (*A, B, Kuo, C.-M.*, et al., *1973: pl. 1, figs. 7, 9, delineated by Tamiko Karr. C, E, Sanzo, L., 1936: pl. 1, figs. 6, 8, redrawn by Tamiko Karr. C, Yashouv, A., and E. Berner-Samsonov, 1970: fig. 5, after Sanzo, L., 1936.*)

ing fry, down to 10 mm TL well inside estuary,[49] suggests inshore spawning.

Ovulated (eggs ripe enough for successful artificial fertilization) female taken 64 km offshore from California over 1645 m water depth.[68] The only other reports of ovulated females inside lagoon of near sea-strength salinity in eastern Sicily,[10] and landlocked in Corsica.[73] Landlocked females reported to begin oogenesis but apparently never to ovulate at various locations.[24,63,124,186] Evidence (fry entering estuaries at less than 15 mm TL) available for inshore spawning in India[49] and South Africa;[61] spawning sites currently debated for Black Sea[65,78,126] and northern Australia;[23,114] evidence favors offshore spawning elsewhere.[1,31,52,84]

Season: Possibly documented as well by season of prejuvenile estuarine entry as by much of literature on spawning itself[2,27] (see Table 1). Smallest prejuveniles probably 15–30 days old, depending on size, and largest near end of season probably 30–90 days old (GED, based on growth in culture[6]).

Four or five peaks per year of migrating, near-ripe adults reported to pass Taiwan, concentrated in successive first and third phases of the moon, first and last peaks small and sporadic, the second yielding in about 10 days approximately 80% of spawners harvested.[31,152] Some females on Texas coast considered "partially spent" as evidence of more than one spawning per female per year,[14] although this not apparent from ovarian study of Black Sea material.[65] Peak spawning periods fairly well established from mid-fall in temperate Australia to early winter in tropical Australia,[79] India[123] and Texas.[14] End of breeding season more diffuse than beginning or peak, probably late fall or early winter in temperate Australia,[28,79] Egypt,[2,124] Israel[2] and North Carolina,[82,84,92] mid-winter in Japan,[96] Taiwan,[31,54] Hong Kong[27] and tropical Australia,[23] early or mid-spring in Hawaii,[119,149] Okinawa,[52] Chile,[157] South Africa,[61,63] West Africa,[19] eastern India,[49,123] South Carolina[12] and Texas,[14,64] and late spring or early summer in western Florida[139] and southern India.[96]

Time: Direct observations of spawning at night.[7,115] Nocturnal spawning and very rapid egg development listed as possible adaptations minimizing probability of eggs being exposed to heavy waves.[126]

Temperature: No direct information; 21 C found most effective to stimulate completion of oogenesis in captive Hawaiian mullet;[149] spawning hormonally induced over range 22.8–23.5 C; [15] optimum temperature for capture of migrating spawners 21–25 C.[31]

Salinity: No direct information; spawning induced in full strength seawater (30–35 ppt) in Hawaii, Taiwan and Israel; [9] fertilization presumed to require high salinity; [159] fish on spawning migration make wide detours to avoid river floodwater.[79] Reported possible breeding in the Colorado River [59] is doubted (FDM, GED).

Fecundity: Estimated at 648±62 eggs per gm. of female body weight; [15,25] in millions of eggs per female .76–1.53,[82] 1.2–2.8,[39,41,79,96] 1.6–4.8,[23] 2.77–4.94 [123] and 3.6–7.2.[142]

EGGS

Location: Accounts differ, reported floating in Black Sea with fat amounting to 6.1% of total egg volume, also with a hydrofuge membrane that attaches to the surface film; [126] in culture floating [106] or sinking [10] (Italy), floating in water of 27 ppt salinity,[18] suspended in circulating water but sinking in still water [54] (Taiwan), suspended in moving water but becoming more buoyant so most float after 12 hours [6,9] (Hawaii), floating first 20–22 hours then sinking to bottom of vessel where they hatched [2,69] (Israel).

Unfertilized eggs: Ovarian eggs nonspherical at 0.57 mm diameter [82] (see oogenesis details [65,101]). Hydration occurring a day or so before spawning.[151] After ovulation eggs spherical, nonadhesive and transparent.[54]

Fertilized eggs: nonadhesive,[18] spherical,[2,10,54,106] transparent,[2,18,54,106] straw-colored; [28] chorion with irregular delicate sculpturing,[18] or without markings, sculpturing [10] or attachment mechanisms except hydrofuge membrane; [126] yolk unsegmented.[2] Oil droplet single if eggs released spontaneously, sometimes several droplets present in artificially removed eggs,[2,9] these can develop normally, droplets coalescing during development.[2] Oil droplet without color,[10] yellowish [18] or light yellow.[54]

Egg diameter 0.60–0.72 mm (Black Sea [11,115]), 0.66–0.72 mm (Israel [2,69]), 0.72–0.807 mm (Italy,[106] Sicily,[10] Corsica [73]), 0.8 mm (India [30]), 0.65–1.08 mm (Japan [51]), 0.898–0.962 mm (Taiwan [2,18,54]), 0.88–0.98 mm (Hawaii [6,15,25]). Oil globule diameter 0.26–0.31 mm (Black Sea [11,115]), 0.28 mm uniform (Italy,[106] Sicily [10]), 0.37 mm (India [30]), 0.36–0.40 mm (Taiwan [18,42,60]), 0.33 mm uniform (Hawaii [6]), 36.1–40.0% of egg diameter (Israel).[2]

EGG DEVELOPMENT

Cleavage meroblastic; [6] first cleavage variously equal [18,54] to unequal; [6,10] perivitelline space minute,[2] appearing 15 [6] to 40 [18] minutes after fertilization.

Incubation time: 38 hours at 23–24 C [106] (Italy), 59–65 hours at 20–24.5 C [18,54] (Taiwan), from 24 hours at 30.6 C to 108 hours at 11.4 C (Hawaii) according to the equation:

$$\log \text{time} = 3.6674 - 1.5240 \log \text{temperature}$$

with maximum survival at 23 C; time at optimum temperature 40–49 hours,[121] thermal optimum strongly peaked at 22–23 C; [9] development very poor below 22 C [18] (Israel). Optimum salinity in range 30–32 ppt, survival percentage reduced from 90% at 32 ppt to 5% at 24 ppt (Hawaii [15]).

Major developmental stages as follows (note variation in time of appearance of Kupffer's vesicle):

At 24 C [6]		21–24 C [18]		20–24.5 C [54]		Stage
Hr.	Min.	Hr.	Min.	Hr.	Min.	
	50	1	10	1	30	2 cell, 1st cleavage
1	05	1	40	1	50	4 cell
1	25	2	10	2	10	8 cell
1	35	2	30	2	30	16 cell
1	50	2	50	2	50	32 cell
2	25					64 cell
2	40					128 cell
3–5		4–5		4–8		Late segmentation, morula
6–7		6–9.5		8–9.5		Blastula
7		9.5–11		9.5–11		Early gastrula, embryonic shield
12		11–14.5		11–14.5		Late gastrula
13	30	14	20	14	30	Neural groove
				15	00	Kupffer's vesicle [54]
14	30	16	15	16	30	Optic vesicles appear, segmentation begins
15	30	18		17	10	Kupffer's vesicle,[18] otic vesicles formed
20	55	26	30	32	40	First melanophores, lens vesicle
25	10	34	10	33	40	Heartbeat commences, first xanthophores
27		40		48		Tail free
		50	40	50		Finfold appears on tail
31	05	55	10	54		Tail reaches head
36		59		59		Hatching begins

Pigmentation: Large, stellate melanophores first evident on oil globule at 9 [106] to 32.6 [54] hours, later on yolk sac beside trunk, along trunk and on interorbital region,[2] becoming denser and more distributed until specimen almost black at hatching; [2,54] light yellow pigment forming breaks in the dark background; [2,10] eyes not differentially pigmented before hatching.[10,18]

YOLK-SAC LARVAE

Hatching length: 2.2–2.5 mm TL (Black Sea,[11] Italy [10,106]), 2.42–2.88 mm TL (Hawaii [6,9]), 2.5–3.5 mm TL (Taiwan [18]),

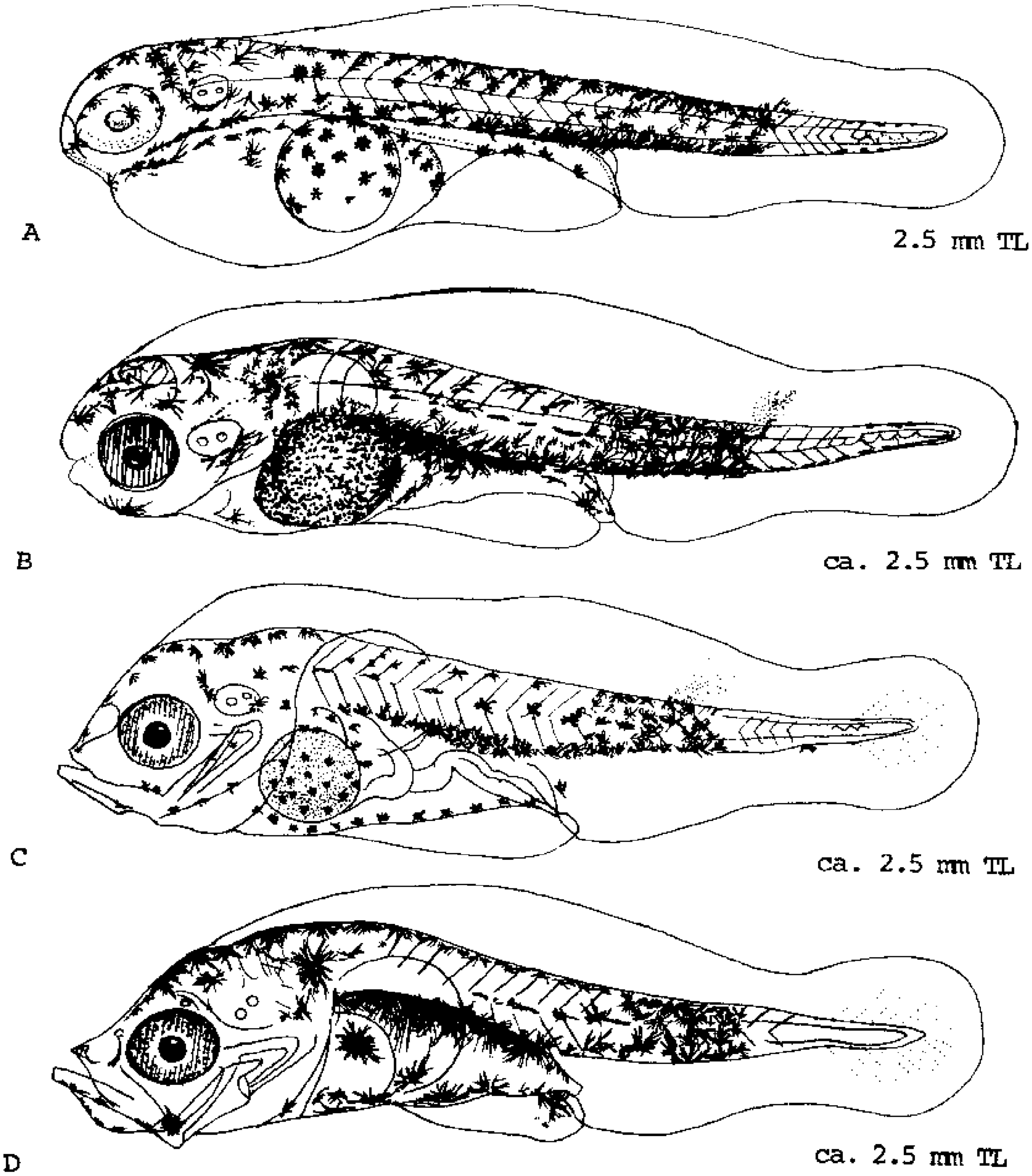

Fig. 24. ***Mugil cephalus***, Striped mullet. A. Yolk-sac larva, newly hatched, 2.5 mm TL. B. Yolk-sac larva, third day after hatching, ca. 2.5 mm TL. C. Yolk-sac larva, fifth day after hatching, ca. 2.5 mm TL. Larva, eighth day after hatching, ca. 2.5 mm TL. (*A-D, Sanzo, L., 1936: pl. 1, figs. 9–12, A-B redrawn by Joan Ellis, C-D redrawn by Tamiko Karr.*)

3.4–3.6 mm TL (Israel [2]). Size at end of stage 3.1–3.5 mm TL; little or no growth during stage, length may even decrease.[6,18] Duration of stage 2–5 days at 20–26 C.[6,9,18,106,146]

At hatching yolk sac ovoid [106] or oblong-ellipsoidal; [2] oil globule near center [2,106] or rear [10] of yolk sac; notochord curved along yolk sac, curvature greater when hatched at lower temperature; gut not well developed; finfold complete,[18] with a short preanal section; myomeres apparently 26 [10] or 28,[106] very difficult to count because of obscuring pigmentation; [54] heart in embryonic position; preanal length greater than postanal length.[10]

At 20–24 C mouth open day 2,[9,106] its width 0.065 mm by day 3; formation of pectoral fins [106] and internal organs evident day 2; gill clefts open day 3 or 4; [18] heart rotation from embryonic position and yolk sac much reduced day 3; dorsal finfold moved somewhat forward on head by day 3; myomeres 24, with 12 caudal, on day 3.[10] Oil globule still present when yolk disappears about day 4.[18,146]

Pigmentation: At hatching stellate melanophores over oil globule, yolk surface and body, fine spots along dorsal and ventral profiles of the caudal trunk, yellow pigment also present.[2,10,18,73,91] Pigmentation increased day 2,[18] especially on brain and eyes.[106] Day 3 black pigment has increased along inferior profile of abdominal trunk, and laterally; a yellowish blotch midway between anus and the caudal extremity extending upward into the dorsal finfold. Intense black pigment over yolk sac in the anterior abdominal region. Some spots in the pectoral membrane. Eyes reflecting silvery by day 3.[10,146]

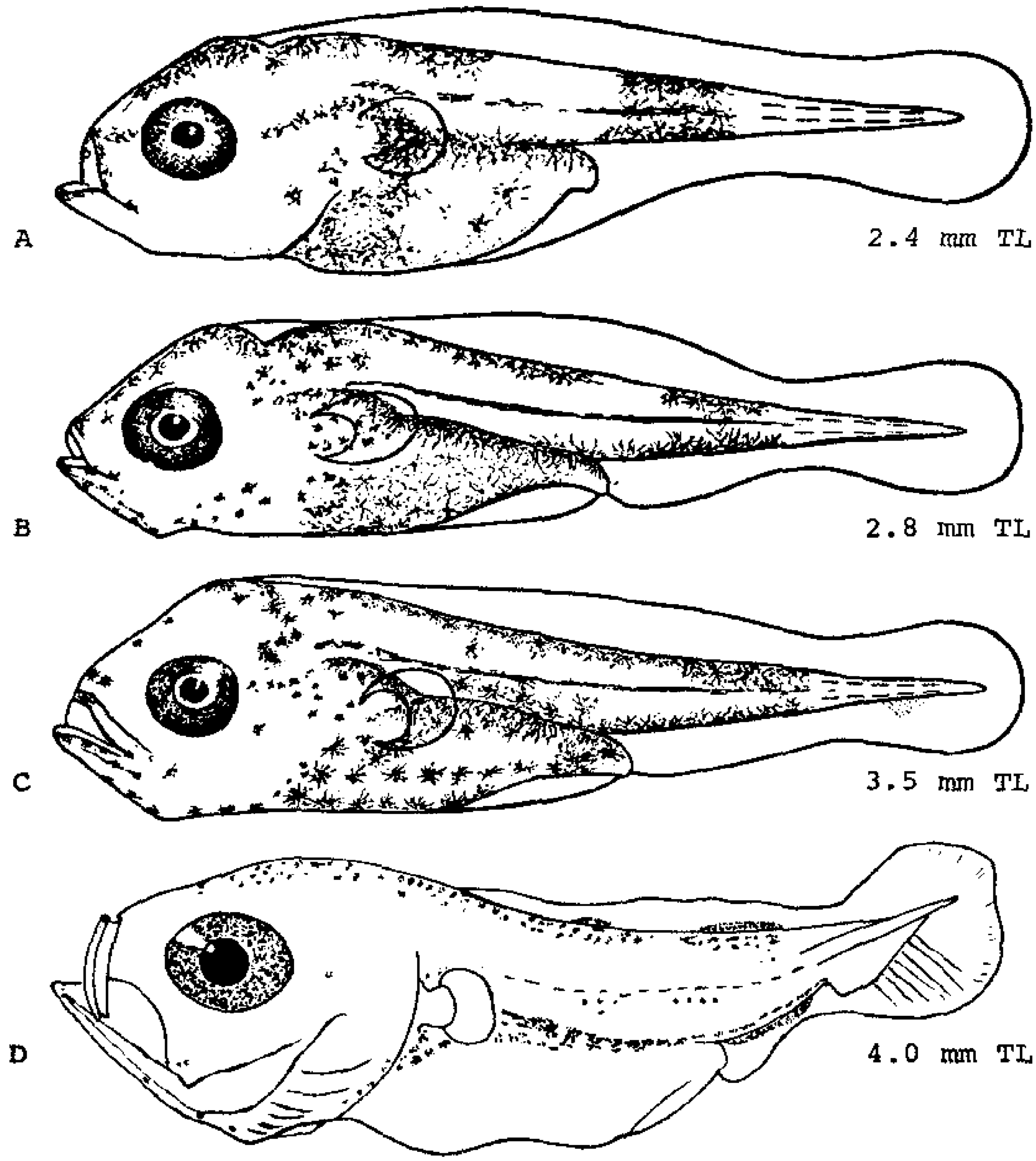

Fig. 25. *Mugil cephalus*, Striped mullet. A. Larva, 2.4 mm TL (Black Sea). B. Larva, 2.8 mm TL. C. Larva, 3.5 mm TL. D. Larva, 4.0 mm TL (southeastern U.S.). (*A-C, Dekhnik, T. V., 1973: pl. 12. D, Anderson, W. W., 1958: fig. 2.*)

LARVAE

Specimens described 3.1–10.9 mm TL. Size at end of stage ca. 11 mm TL (9 mm SL). Duration of stage ca. 20–24 days in culture (ending day 24–28).[18,91]

Caudal rays formed first, ca. 7 at 4.0 mm TL; 14 principal and ca. 3 ventral secondary rays at 5.4 mm TL;[1,18] 1 additional ventral and 4 dorsal secondary rays at 7.9 mm TL,[1] final count also reported as 20 at 8.25–10.9 mm TL. Second dorsal with 7–9 bases countable between 4 and 5.7 mm TL;[18] not countable at 4.0 mm TL but with 9 well formed rays at 5.4 mm TL. First dorsal with 4 bases countable at 5.4 mm TL; 4 well developed spines at 6.7 mm TL. Anal bases not developed at 4.0 mm TL; 11 developed rays at 6.2 mm TL; last ray branched at 7.9 mm TL. At 4.0 and 6.7 mm TL pectorals rayless and fleshy; 9 or 10 rays in the upper part at 7.9 mm TL. Pelvic buds not present at 4.0 mm TL; buds evident by 5.4 mm TL; some rays formed at 7.9 mm

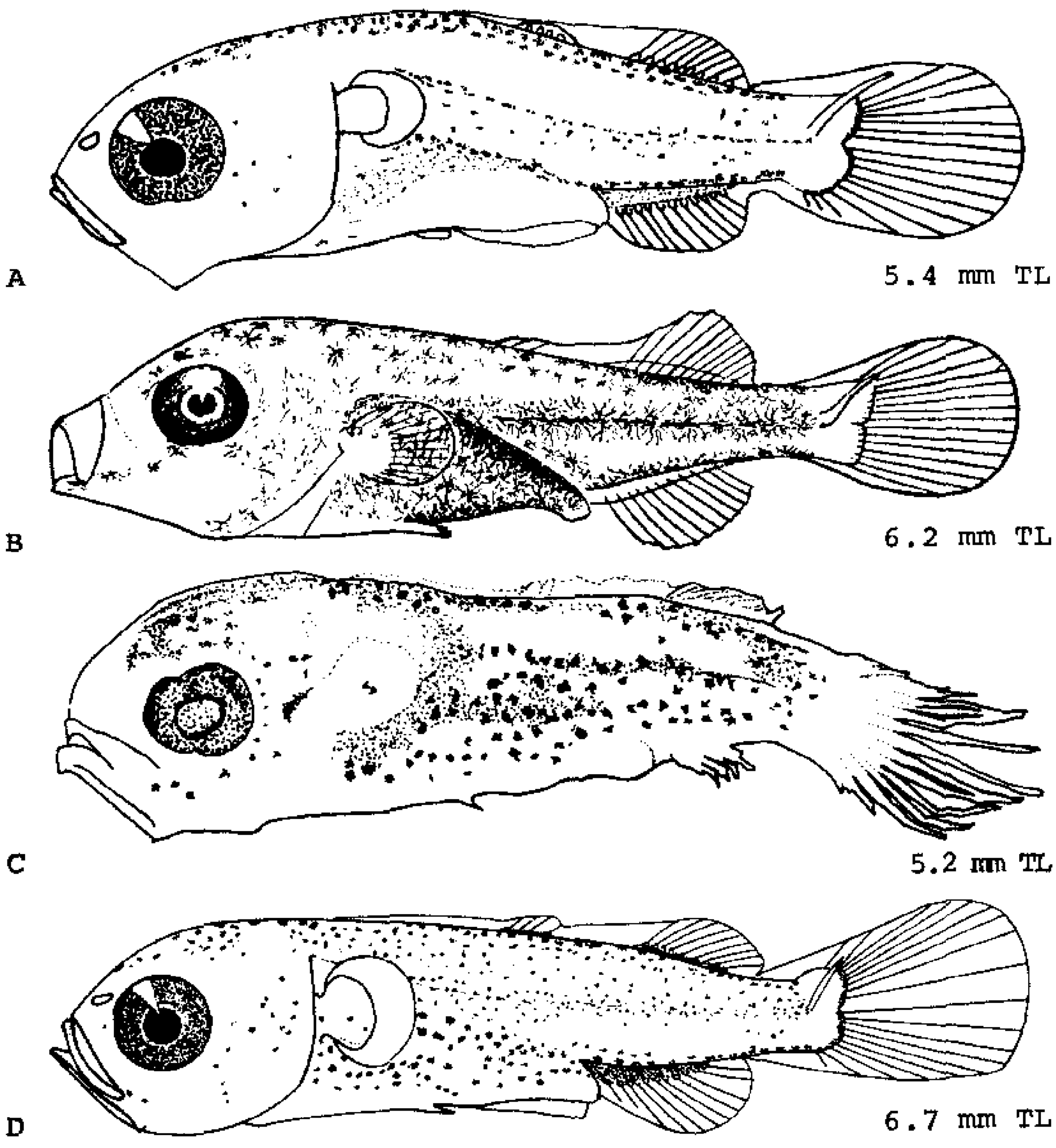

Fig. 26. *Mugil cephalus*, Striped mullet. A. Larva, 5.4 mm TL. B. Larva, 6.2 mm TL (Black Sea). C. Larva, 5.2 mm TL, note advanced development at smaller size (Japan). D. Larva, 6.7 mm TL (Southeastern U.S.). (*A, D, Anderson, W. W., 1958: figs. 3, 4. B, Dekhnik, T. V., 1973: pl. 12. C, Imai, S., 1958: pl. 46, delineated by Tamiko Karr.*)

TL;[1] 6 rays present at 10.9 mm TL.[18] Myomeres 24 total, 11 preanal on day 8[10] (ca. 3–4 mm TL[18]).

Preanal length considerably greater than postanal length on day 5, less so on day 8.[10] At 10 mm TL (as % of TL) head 28.6, body depth at first dorsal less than 20; eyes ca. 33% of head length.[116]

Feeding on day 5,[6,10,18] but not intensively until day 9;[6] Meckel's cartilage and branchial cartilage evident day 5;[10] gill filaments forming at 3.35–3.8 mm TL (day 8), lamella on gill filaments at 3.85–5.7 mm TL (days 14–15);[18] gape measuring .636–.882 mm (15% of TL) at 5.2 mm TL;[33] oil globule still present after disappearance of yolk day 5, finally gone day 8[18] or 9;[6] stomach, intestine, spleen, gall bladder and swim bladder forming at 3.06–3.4 mm TL (day 5);[18] urostyle flexion begins before 4.0 mm TL;[1] hypurals forming days 8[10] to 13[18] at 3.45–5.10 mm TL;[1,18] cephalic portion of finfold nar-

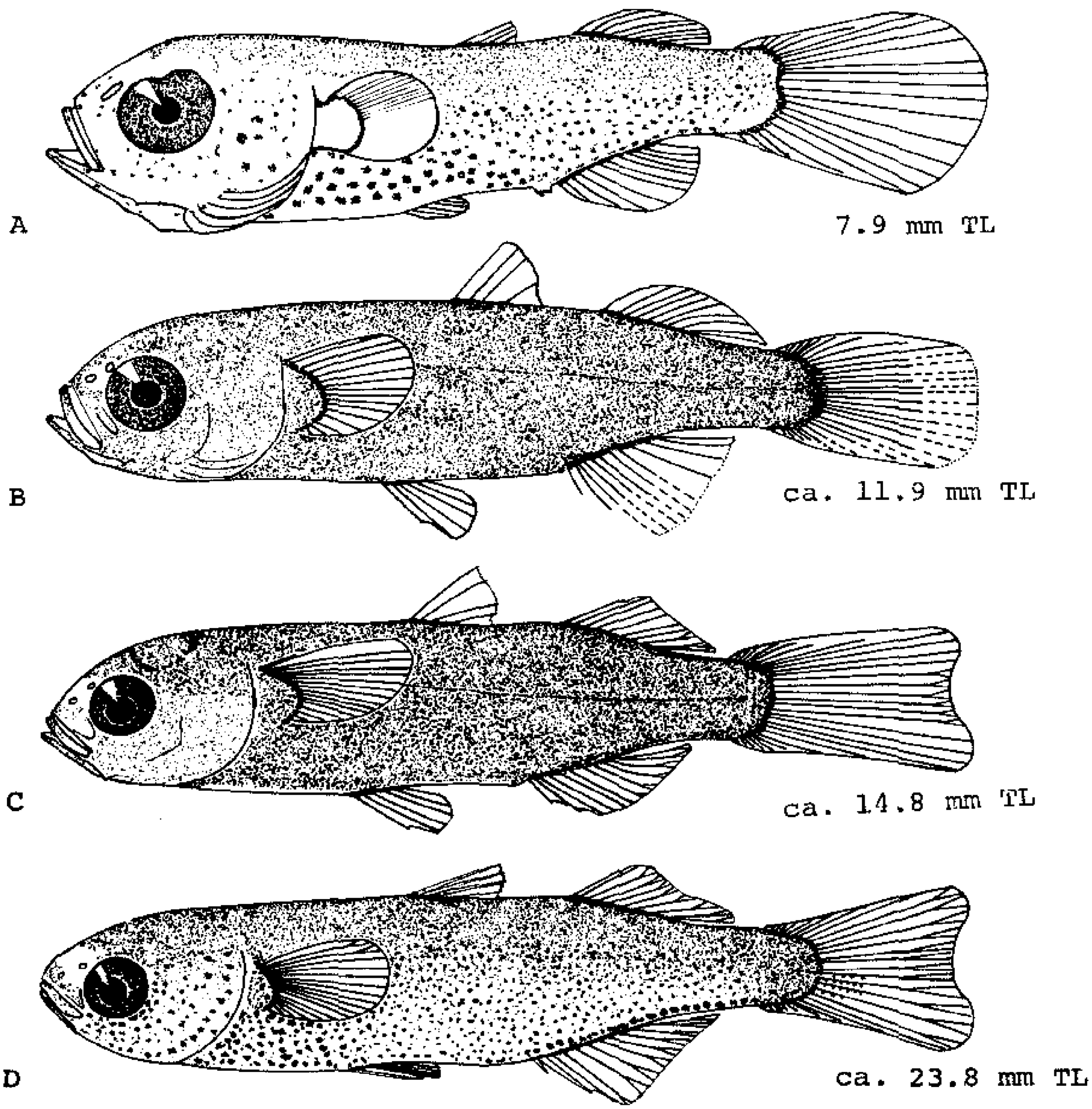

Fig. 27. *Mugil cephalus*, Striped mullet. A. Larva, 7.9 mm TL. B. Prejuvenile, ca. 11.9 mm TL (9.7 mm SL). C. Prejuvenile, ca. 14.8 mm TL (12.1 mm SL). D. Prejuvenile, ca. 23.8 mm TL (19.8 mm SL). (*A-D, Anderson, W. W., 1958: figs. 5–8.*)

rowed and notably raised day 5,[10] some finfold still present between median fins at 6.7 mm TL, almost gone[18] or gone[1] at 8.0 mm TL; nostril single and oval in shape at 5.4 mm TL; teeth absent throughout stage;[1] scales beginning to develop between 8 and 10 mm TL[10,91] or SL.[1] Elongate, non-wettable patches present on either side of dorsal fin, carrying films of air suggested to function as an accessory hydrostatic organ (Black Sea).[126]

Pigmentation: Strongly pigmented in black and yellow at 2–5 mm TL;[73] black pigment reduced on abdomen day 5, but augmented on the ventral profile and aligned along the course of the future lateral line; a large dark blotch persisting behind the anus the height of the trunk, with a yellow patch behind it extending into the dorsal finfold; diffuse yellow color present on head and trunk.[10] By day 8 (ca. 3.5 mm TL[18]) melanophores even more strongly branched, especially on abdomen; yellow patch no longer apparent in dorsal finfold.[10] Surface dark in color by 3.45–5.10 mm TL (days 10–13). At 5.4–6.6 mm TL (days 16–19) dark spots scattered over body; shiny silver-white[18] or silvery green[91] color developing ven-

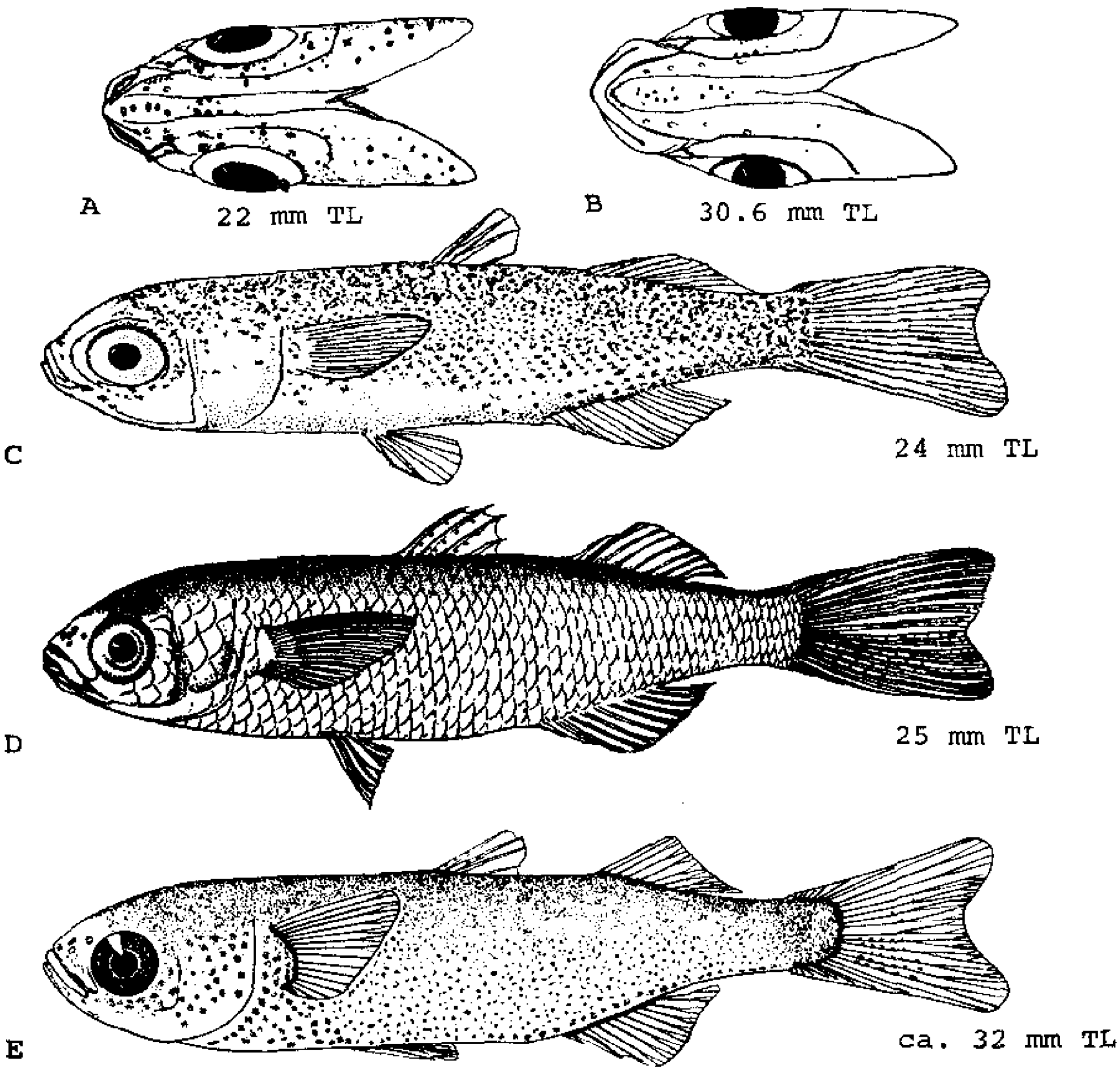

Fig. 28. *Mugil cephalus*, Striped mullet. A. Prejuvenile, ventral view of head at 22 mm TL (Israel). B. Prejuvenile, ventral view of head at 30.6 mm TL. C. Prejuvenile, 24 mm TL (Italy). D. Prejuvenile, 25 mm TL (eastern U.S.). E. Prejuvenile, ca. 32 mm TL (southeastern U.S.). *(A, B, Perlmutter, A.,* et al., *1957: pl. 3, figs. D, F. C, Vialli, M., 1937: pl. 34, fig. 17, retouched. D, Hildebrand, S. F., and W. C. Schroeder, 1928: fig. 111. E, Anderson, W. W., 1958: fig. 9.)*

trally from gill cover to anus. At 6.0–7.65 mm TL (days 20–21) color appeared brown at times and silvery green at other times. At 8.25-10.9 mm TL (days 22–24) color noted as silvery white (Taiwan),[18] also reported at 10 mm TL as uniformly brownish with points and blotches of pigment in scattered groups (Italy).[146]

PREJUVENILES

Size range: Ca. 9–44 mm SL (11–52 mm TL).[1,23] Specimens described 9.7 mm SL (11.9 mm TL) to ca. 44 mm SL (52 mm TL). Estimated duration of stage variable with temperature and other factors, age probably 30–90 days at end of stage (GED).

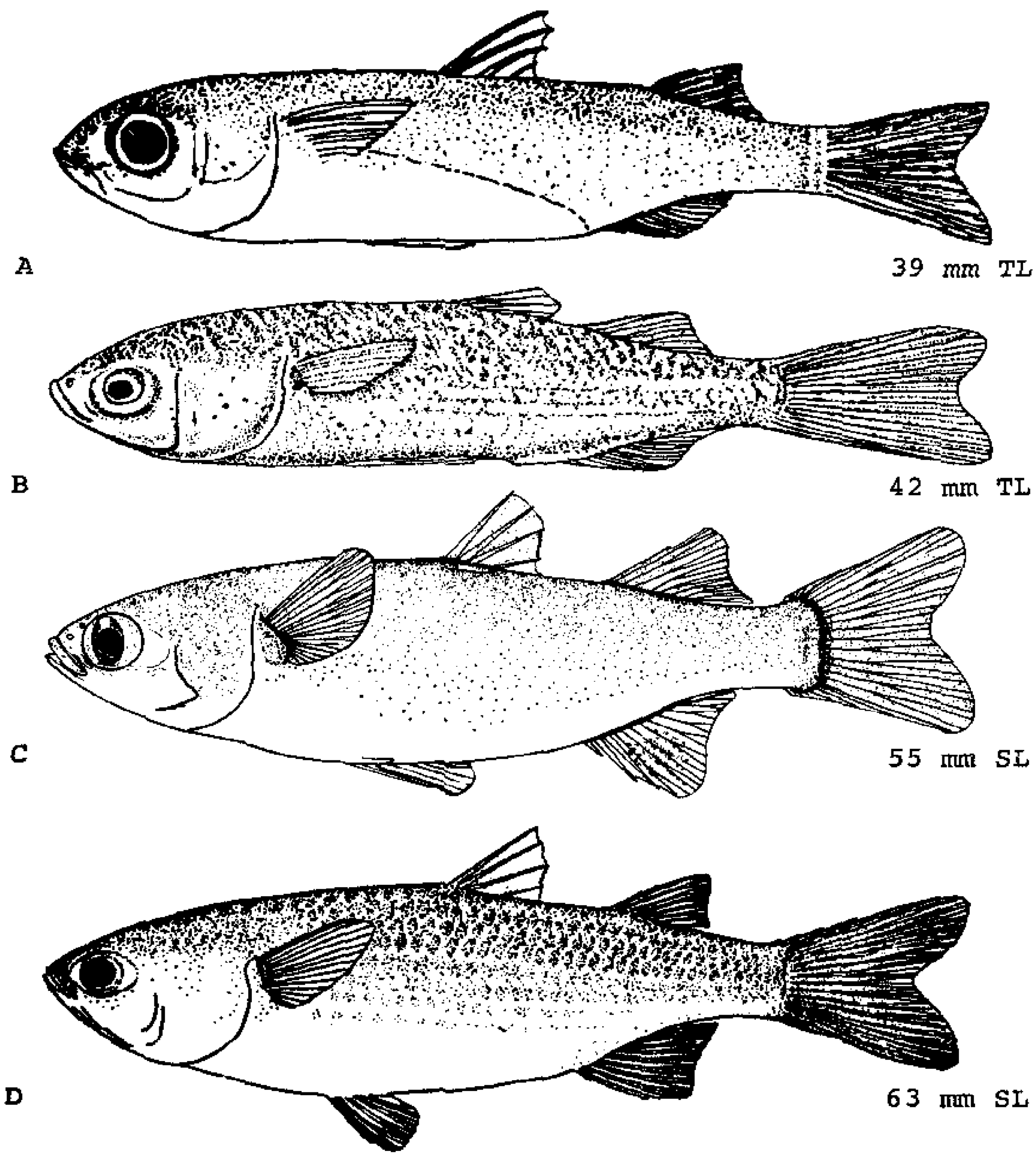

Fig. 29. *Mugil cephalus*, Striped mullet. A. Prejuvenile, 39 mm TL (Israel). B. Prejuvenile, 42 mm TL (Italy). C. Juvenile, 55 mm SL (southeastern U.S.). D. Juvenile, 63 mm SL. (*A, Perlmutter, A., et al., 1957: pl. 3, fig. A. B, Vialli, M., 1937: pl. 34, fig. 19, retouched. C, Anderson, W. W., 1958: fig. 10. D, Kilby, J. D., 1949: pl. 1, fig. a.*)

Modal counts: D. IV, I, 8; A. II, 9, changing at end of stage to III, 8; C. 29, principal rays 14, secondary rays 7 dorsal and 8 ventral; P. 16–17; V. I, 5; number of elements established by 9.7 mm SL.[1] Scale rows 42 longitudinal, 14 transverse.[84] At 25–34 mm SL primary teeth in upper row 20–29, mandibular row 6–15, upper secondary teeth 0–15; [34] at 19 mm SL ca. 16 teeth on tongue.[1]

Scales forming at ca. 11 mm TL,[18,41] the largest measuring 0.40×0.25 mm with 1–3 circuli; [18] until after ca. 30 mm TL characteristically distinct in form from those of juveniles and adults, the posterior exposed region crowded with incomplete circuli that are interrupted in the middle portion of each scale.[84,99,156] At 9.7 mm SL (ca. 11.9 mm TL) nostrils double with well-separated openings; teeth still absent; the full complement of fin rays formed; last soft dorsal ray branched to its base (only the last anal ray branched previously); preorbital unserrated, serrations first evident between 15 and 19 mm SL.[1]

Further fin ray branching as described:

> Caudal—6 middle rays at 12.1 mm SL; all 12 middle rays by 19.8 mm SL.
>
> Soft dorsal—the eighth (secondary branching) and seventh rays at 12.1 mm SL; the posterior 7 rays by 19.8 mm SL; first ray barely branched by 26.9 mm SL.
>
> Anal—secondary branching on both halves of last ray [1] (important generic characteristic in this family [5]) and the 4 rays before it at 12.1 mm SL; last 8 rays by 19.8 mm SL.
>
> Pectoral—a progression throughout stage beginning dorsally by 19.8 mm SL and ending ventrally after juvenile transformation.[1]

Head scales well developed by 21 mm TL except for a rostral band without scales that narrows somewhat during the stage. Throughout stage depth at first dorsal increasing in proportion to length, and preanal length increasing more rapidly than postanal length.[146] Adipose eyelid evident microscopically by [84] or before [146] 28 mm TL, its anterior lobe beginning to grow over eye at ca. 30 mm TL, the posterior lobe at ca. 39 mm TL; [84,125] eyelid noticeable macroscopically by 42 mm TL.[146] During stage pectoral gradually becoming more pointed, soft dorsal and anal borders more concave, and caudal more deeply forked.[1] From ca. 41 to 50 mm TL third anal ray changing to a spine by deposit of hard material in the articulations, the breaking off at an articulation, and subsequent sharpening of the point.[84,104]

Pigmentation: Features basically similar in various accounts but sizes vary. Ground color grayish white at 12.85 mm TL; [91] silvery green from 8 to 15 mm TL; grass-green, but showing silvery white, after 16 mm TL; [18] from 16 to ca. 40 mm TL brilliant silvery ventrally and laterally, showing flashes of pale whitish blue, progressively duller dorsolaterally until the color reaches a dusky tan on the dorsal surface; [60] at 21 mm TL brownish on the back, silver ventrally; [146] at ca. 23–32 mm SL silvery sides sharply defined from the dark brownish green back; [36,83] entering a dusky phase after 32 mm TL.[84] A longitudinal dark trace reported on the flanks posterior to the first dorsal at 22 mm TL, weak at 28 mm TL, gone at 33 mm TL,[26] a similar trace figured at 9.7 and 12.1 mm SL.[1] Rarely showing even a hint of adult stripes before a transition at ca. 30–35 mm SL [63] (40 mm SL [60]) after which stripes become more evident. A conspicuous iridescent spot usually present between eyes at 40 mm SL or less, and an orange-red spot between posterior margin of eyes up to ca. 35 mm SL.[60] Iris golden [36] or silver-white, adjacent tissues silver.[60] At 22 mm TL pigmentation sparse on lower side of head, steadily decreasing until only a very few melanophores remain at 30 mm TL, concentrated mostly in gular region; never pigmented on mandible.[108] Fins transparent at 22 mm TL, but by 28 mm TL [26] (or beginning as early as 21 mm TL [146]) the first dorsal fin macroscopically showing large numbers of isolated melanophores,[26,146] numerous smaller chromatophores evident microscopically in caudal fin.[146] A discrete caudal spot reported at 22 mm TL, losing intensity at 28 mm TL, no longer evident at 33 mm TL,[26] such a spot figured at 19.8 and 26.9 mm SL.[1] Fine punctulation invading second dorsal and anal fins by 33 mm TL.[26]

JUVENILES

About 44–200 mm SL.

Fins same as adult.[1] At 49 mm SL primary teeth 58 in upper row, 45 in lower, increasing in number at larger sizes; [34] gill rakers increasing from ca. 32 at 59 mm SL to 48 at 117 mm SL.[1] For morphometrics see Table 2; preanal length increasing more rapidly than postanal length.[146]

Caudal fin achieving its final form at ca. 110 mm FL; the ciliate teeth becoming more embedded in the lip with age; [26] teeth on tongue completely covered with flesh by end of stage; [1] snout less curved after 42 mm TL than before, the scaleless rostral band narrower; [146] ring of adipose eyelid becoming elliptical with long axis vertical by ca. 54 mm TL, the posterior lobe elongated and eyelid assuming its typical form by 60 mm TL; [83] scales changing suddenly from those of prejuvenile above 30 mm TL, circuli of the posterior (exposed) region becoming complete and less densely packed than those of the anterior region [84,99,156] (see Fig. 31).

Pigmentation: Generally like adult; lateral stripes increasingly distinct from 44 to 60 mm SL.[60]

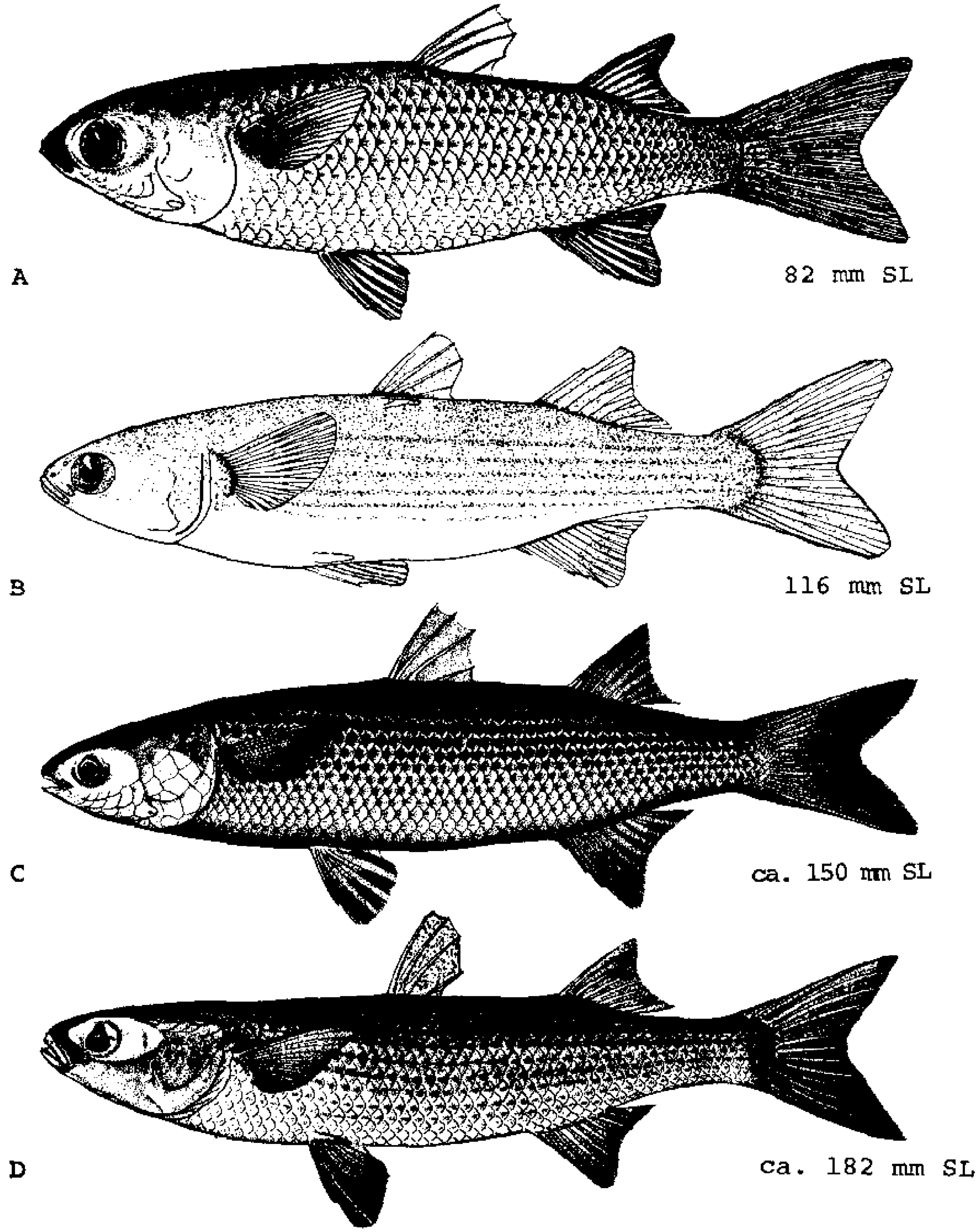

Fig. 30. ***Mugil cephalus***, Striped mullet. A. Juvenile, 82 mm SL. B. Juvenile, 116 mm SL. C. Juvenile, ca. 150 mm SL (northeastern U.S.). D. Juvenile, ca. 182 mm SL (Japan). (*A, Kilby, J. D., 1949: pl. 1, fig. d. B, Anderson, W. W., 1958: fig. 11. C, Goode, G. B., 1884: pl. 179. D, Okada, Y., 1959–1960: fig. 106b.*)

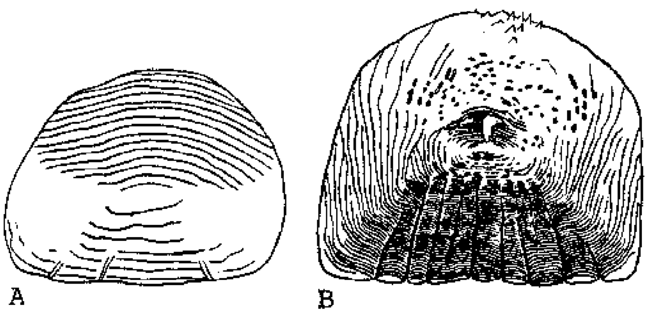

Fig. 31. *Mugil cephalus*, Striped mullet. A. Prejuvenile, scale of 23 mm TL specimen, x 67.5. B. Juvenile, scale of 70 mm TL specimen, x 26. *(A, B, Pillay, T. V. R., 1951: fig. 3.)*

GROWTH

Some evidence that prejuveniles in marine environment grow little in winter, 2–3 mm per month in spring;[32,124] winter growth depression or cessation in older stages apparent generally;[17,32,119] growth also depressed during hot weather in Florida,[21] Texas,[17] India[97] and Egypt;[143] a growth lag at attainment of sexual maturity.[23] Reported growth rates vary widely with climate and other factors[17,19,23,31,41,87,90,102] (selected references); growth of some body proportions shows allometry (see table 2).

TABLE 2. Comparison of proportions (mean part dimension as a percent of mean standard length) for *Mugil cephalus* of various sizes.[23]

Parameter	Prejuveniles	Juveniles	Adult males	Adult females
Sample size	32	46	32	36
Size range (SL)	12.8–44 mm	48–189 mm	260–379 mm	252–508 mm
Head length	33.6%	27.3%	24.8%	24.1%
Snout length	7.9	5.1	4.7	4.6
Eye diameter	9.6	8.1	6.3	6.0
Interorbital width	13.7	12.9	13.0	13.0
Depth at first dorsal origin	27.7	27.3	23.4	23.8
Snout-vent length	70.6	68.5	67.7	68.8
First predorsal	54.0	50.6	49.3	49.4
First dorsal base (without posterior membrane)	5.8	6.5	6.4	6.5
First dorsal height	12.8	15.4	13.7	13.2
Second predorsal	75.0	74.1	73.6	74.1
Second dorsal base	11.0	10.5	10.9	10.9
Second dorsal height	13.5	16.3	14.5	13.8
Preanal (fin)	71.9	70.3	70.4	71.6
Anal fin base	13.2	12.3	12.1	11.8
Anal fin height	16.1	17.0	14.5	13.7

AGE AND SIZE AT MATURITY

Age ca. 1–7 years in males, 2–8 years in females;[94,129,142,159] individual variation great;[129] youngest in India,[94] Egypt[129] and probably West Africa,[19] oldest in Black Sea.[142] Size 200–355 mm SL,[36] or males 230[159]–534 mm FL,[63] females 240[159]–614 mm FL;[63] not less than 300 mm in Australia,[23] Turkey[40] or South Africa;[63] one exceptional female mature at 150 mm SL.[101]

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Mugil curema Valenciennes, White mullet

ADULTS

D. IV-I, 7–9 (mode 8); [35,37] A. III, 9 [21,35] (rarely III, 8 [23]); P. 15–18 (mode 17); [35,37] V. I, 5; [38] C. 28–30 (7–8+7+7–8); [36] vertebrae 11+13 [4] or 12+12; [36] lateral line scales 37–39 (mode 38) [26] rarely to 35 [29] or 45; [35] transverse scale rows 12,[18,22] cheek scale rows 2; [37] gill arches 4 on each side; gill rakers ca. 65; [38] primary teeth 40–63 in upper jaw, 74–115 in lower jaw; secondary teeth, 4–68 in upper jaw (row sometimes absent or partial); [11] no teeth on vomer or palatines; [36] hypurals 4, 2 dorsal and 2 ventral.[4] Head 24.3–27.8% of SL.[21,31] Proportions as percent of HL: Snout 16.7–23.0, eye 23.0–31.7, interorbital 34.5–41.7,[21] anal base 60, first dorsal spine 66. Last dorsal spine less than half length of first dorsal spine.[31]

Body compressed, moderately elongate; ventral profile more convex than dorsal profile; caudal peduncle rather strongly compressed.[21,37] Head at eyes scarcely deeper than broad; snout short; [21] interorbital slightly convex; [37] preorbital serrate.[37] Mouth moderate, subinferior, oblique; the lower jaw included; [21] upper lip thin; maxil-

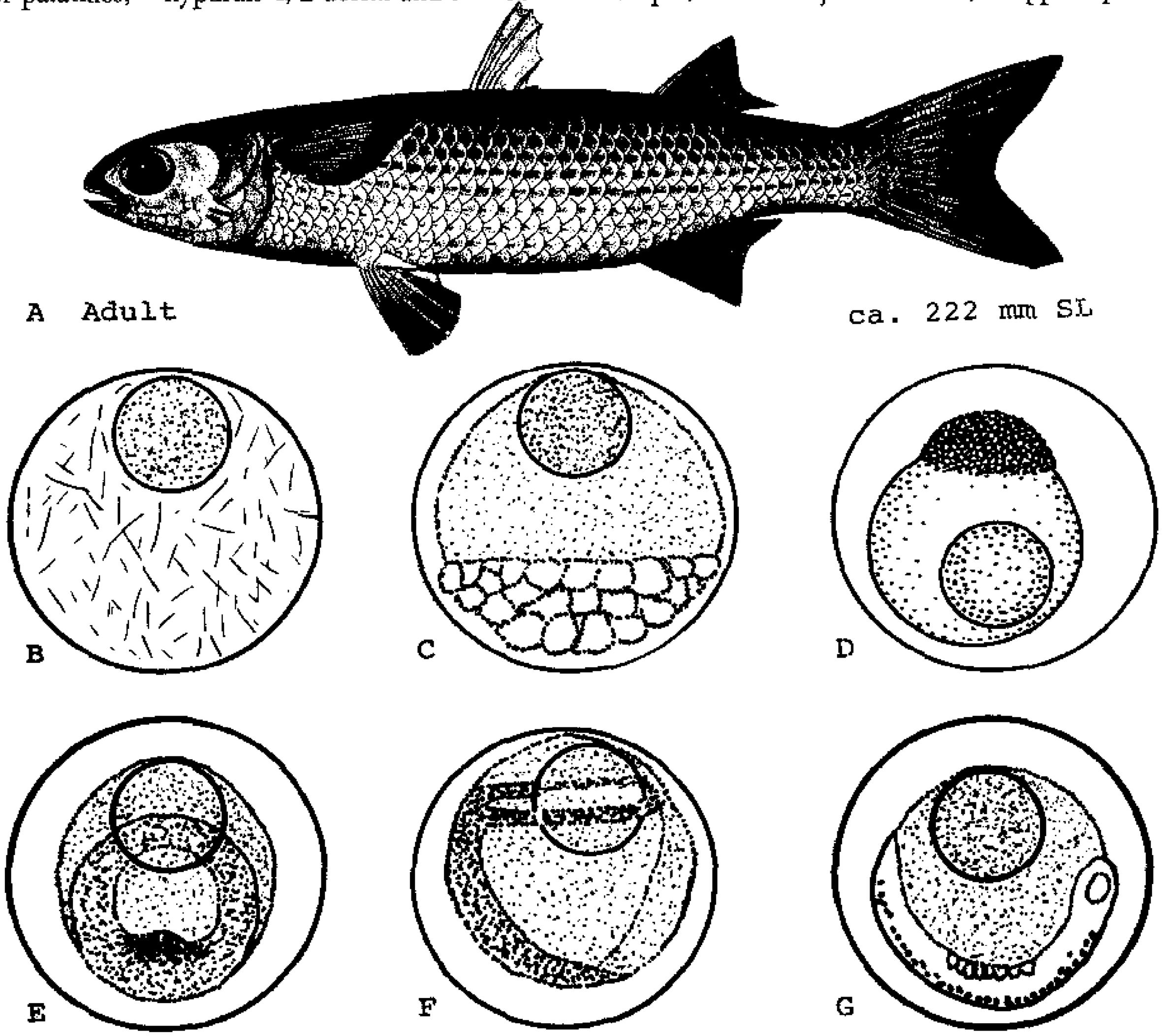

Fig. 32. *Mugil curema*, White mullet. A. Adult, ca. 222 mm SL. B. Unfertilized egg, diameter ca. 0.82 mm. C. Thirty-two cell stage, 2 hours after fertilization, diameter ca. 0.90 mm. D. Morula, diameter 0.88 mm. E. Blastula, segmentation cavity forming, 8 hours post-fertilization, diameter ca. 0.90 mm in this and succeeding embryonic stages. F. Gastrula, embryonic shield, 12 hours post-fertilization. G. Blastopore closed, 8 somites visible, 16 hours post-fertilization. (*A, Goode, G. B., 1884: pl. 179. B, C, E–G, Anderson, W. W., 1957: fig. 2. D, Rass, T. S., 1972: pl. 4.*)

lary reaching below eye;[37] gape wider than deep;[21,38] primary jaw teeth moderate in size, simple;[11] in a single irregular labial row;[37] secondary teeth also simple, in a single, very irregular row well separated from the primary row; pharyngeal teeth similar to jaw teeth in appearance;[11] gill openings wide; gill membranes free from the isthmus; gill rakers numerous, slender, close-set.[21] An adipose eyelid, similar to that of *M. cephalus*, well developed in adults. Scales rather large,[38] weakly ctenoid[18] but ctenii noticeable to touch (RHM), with crenate, finely serrate, membranous edges.[21,38] Pectoral fins above midline, in the majority of adults not quite extending to level of first dorsal origin;[38] pelvic fins subabdominal, inserted about midway between tip of snout and anal fin origin; first dorsal fin origin about midway between snout tip and caudal base; second dorsal fin slightly behind anal fin origin; anal fin similar to second dorsal in shape but longer; caudal moderately forked. Second dorsal and anal fins densely and almost completely covered with fine scales, which extend also on the caudal base.[21,23,26,37,38]

Pigmentation: Color above bluish,[31,38] greenish[21] or olive with bluish reflections,[28] silvery elsewhere;[21,23,31,38] lacking the dusky streaks along the scale rows characteristic of *M. cephalus;*[23,31,38] opercle yellowish[21,31] or golden, the color diffuse;[29] pelvic and anal fins pale;[23,31,38] caudal fin yellowish at the base, pale centrally, with a dusky[22,23,31] or dark[8,17] margin; dorsal and pectoral fins dusky; axil of pectoral bluish black,[17,38] in south Texas this patch lighter than same for *M. cephalus* (RHM); peritoneum jet black.[38] A distinct bright gold or yellow spot behind opercle of individuals between 18–320 mm SL (at least). Lost after preservation. Gold pigment in iris restricted to a spot above pupil. This usually remains obvious in preserved fish (RHM).

Maximum size: Said to reach 914 mm,[23] but typical sample maxima 355–360 mm SL in the Atlantic,[17,27,38] 385 mm SL in the Pacific.[38] Adult size usually 200–260 mm SL.[22,27]

DISTRIBUTION AND ECOLOGY

Range: Western Atlantic from Massachusetts[5] and Bermuda[23] to Santos, Brazil;[21] eastern Pacific from the Gulf of California to Iquique, Chile;[46] west coast of Africa.[27,29]

Area distribution: Adults rare even as far north as Beaufort, North Carolina,[18] but immature individuals fairly common along the mid-Atlantic coast north at least to Long Island;[6,31,39] reported in small numbers from Chesapeake Bay.[21]

Habitat and movements: Adults—coastal waters generally, including beaches, bays, lagoons, salt marshes, mangrove swamps and tidal rivers; prevalent in dirty water and over mud bottoms in the tropics and along the Gulf coast, but also frequenting clear water over bottoms of sand, coral or stones;[15,17] sometimes encountered in pelagic schools in open water near coasts;[17] entering streams less frequently north of Florida.[8,10,25]

Temperatures reported for this species not correlated with life history stage, samples at 19.5 C[40] or 19.0 C and 36 C[8] may include adults. Large *M. curema* reportedly subject to selective cold kills in Alabama rivers.[25] Minimum temperature for activity of "large" juveniles and adults at 10–12.5 C in winter in south Texas.[3]

Salinity 0–50 ppt; salinity distribution more restricted in non-tropical parts of the species range.[8,34]

Movements of all age groups suggested to be controlled by temperature in Texas;[12] winter movements and habitat incompletely understood, but numbers in estuarine habitat decrease in colder months,[8,18] even in Florida.[40]

Larvae—yolk-sac stage floating;[2] larvae less than 10 mm SL all taken in surface nets from offshore marine waters, off the southeastern U.S. from near the 37 m (20 fathom) line to the axis of the Gulf Stream,[2,7] ca. 90 km out over 1051 m depth in the Gulf of Mexico,[1] ca. 4.8 km from shore near Bermuda.[4] Temperature 20.7–29.0 C. Salinity 34.0–36.3 ppt.[2] Movements of larvae not studied extensively, probably controlled by prevailing currents (GED). Occurrence reported in every month, peaking in April–May;[2,7,9] winter records[7,9] possibly needing additional verification (GED).

Prejuveniles—pelagic, marine, moving inshore at 17–25 mm SL;[2] usually reaching coastal areas at 23–25 mm SL;[1] an isolated record inside a Florida estuary at 11 mm TL;[16] largest records offshore 36.5 mm FL[7] and 25 mm SL.[2] Adopting shallow water a few centimeters deep along the edges of beaches, canals and lagoons;[17,24] often remaining near inlets;[8] over mud bottoms in Mississippi and Florida[16,24] but preferring sand-filled to natural bottoms in New York.[39] Temperature 6.0[44]–39.0 C.[35] Salinity not size correlated; at least one prejuvenile at 0–8.7 ppt in North Carolina.[28]

Movements consisting of migration from marine waters to estuarines and lagoons; migration seasonal, in Florida March–October, peaking in May;[14,16,24,41] in North Carolina,[28] Mississippi[15,35] and Texas[8,12] April–October, peaking in June or July; in Long Island, New York, July–September, peaking in July;[39] in Puerto Rico year round, peaking in July;[30] a separate, smaller influx between August and October following the early peak in some areas;[2,8,28] a single December collection reported in North Carolina.[44]

Juveniles—habitat similar to that of juvenile *M. cephalus*, but where the two species occur together *M. curema* less common at both extremes of salinity and at low temperatures;[8,13] locally abundant in and near passes and inlets in Texas;[8,32] entering rivers for long distances in Florida,[14] tidal parts of rivers in Alabama[25] and North Carolina;[28] taken over mud bottoms in Mississippi[15] and Florida,[24] much more common over sand-filled bottoms than over natural bottoms in Long Island, New York.[30] Temperature 5.0[33]–35 C.[8] Salinity 0[28]–49 ppt.[30]

In Texas a size class modally 63–68 mm TL entering bays along with prejuveniles starting about May, leaving about October when temperatures drop.[12] In North and South Carolina second season fish uncommon, first year juveniles leaving October and November.[18,28,43] From Maryland[6] to Long Island[30] first year juveniles common in September, seldom taken after October. Fall migration thought to be southward toward or to Florida along Atlantic coast, this not documented.[2,19]

SPAWNING

Location: Only eyewitness report at surface over 37 m of water off southern Florida.[2] Offshore elsewhere by implication from larval occurrences.[1]

Season: Spawning seen on April 25;[2] in south Florida spent females first observed in April, last ripe females in June, spawning peak estimated to occur in May;[27] in Texas near ripe and ripe females predominant in February–March, first spent females in April–May, few ripe females available for capture from June to September, a second influx of spent females in October–November;[6] on combined evidence season considered late March or early April to September with peak during April, May and June[2] (a few larvae and prejuveniles taken in winter[7]).

Time: Observed at 2200–2315 hours.[2]

Temperature: Not reported for the observed spawning; temperature rise above 20 C suggested to trigger spring onset of spawning season.[2]

Salinity: Seawater, no detailed information.[2]

Fecundity: No information.

EGGS

Location: Pelagic[2] (presumably near or at surface, GED).

Unfertilized eggs: Diameter 0.77–0.86 mm (average 0.82 mm); oil globule 0.27–0.32 mm (average 0.30 mm); yolk appears as an unsegmented, opaque mass with little, if any, perivitelline space; oil globule pale yellow, located at the top of the yolk mass; surface of chorion with a finely scratched or etched appearance.[2]

Fertilized eggs: Water absorbed in first 2 hours with development of a perivitelline space ranging from 0.04 to 0.12 mm wide, varying as development proceeds; yolk unsegmented; oil globule single. Egg diameter 0.86–0.92 mm (average 0.90 mm) after 2 hours. Oil globule 0.27–0.32 mm (average 0.30 mm). Egg and oil globule diameters relatively invariant from this stage until hatching.[2]

EGG DEVELOPMENT

Eggs examined at 2 hour intervals from fertilization to hatching at 40 hours; temperature unspecified.

2 hours—32 blastomeres, perivitelline space developed.

4 hours—morula well formed and berry-like in appearance.

8 hours—segmentation cavity forming.

12 hours—embryonic shield well advanced.

16 hours—8 somites; blastopore closed; optic vesicles defined; irregular lines of pigment spots on dorsal surface, one on each side of the notochord from behind head onto caudal trunk.

24 hours—tail free; lens vesicles present; 24 myomeres discernible; dorsal rows of melanophores more closely set, extending from just behind eyes to level of junction between tail and yolk mass.

32 hours—finfold developed; tail free, about one-third body length; dorsal pigment rows still present, also melanophores present on the lateral and ventral aspects of the embryo.

40–42 hours—hatching.[2]

YOLK-SAC LARVAE

Hatching length: 1.63–1.76 mm TL (N=3). Size at end of stage: 2.49–2.68 mm TL.[2]

At hatching mouth and fins undeveloped; eyes unpigmented; oil globule located in posterior half of the yolk sac.[2]

After 4 hours body longer, 1.74–2.15 mm TL (average 1.89 mm TL, 11 specimens); yolk mass considerably shrunken; finfold more developed and beginning to constrict in the caudal region. At 16 hours further length increase, 2.30–2.47 mm TL (average 2.36 mm, 7 specimens); yolk mass more reduced; finfold has reached maximum development. At 32 hours length 2.49–2.68 mm TL (average 2.56 mm TL, 6 specimens); minute pectoral buds present; lab specimens dying rapidly; no further changes before last individual died at 45 hours. In plankton tow material, a 2.56 mm TL individual had eyes still unpigmented; undifferentiated mouth; reduced yolk mass; oil globule shrunken somewhat but still present; finfold more constricted in the region of the caudal peduncle. A second individual also 2.56 mm TL had a distinct head; head and body anterior to the anus noticeably thickened; mouth and operculum developed; pectoral enlarged into a fleshy-based, fan-shaped fin without rays; yolk largely absorbed; oil globule still visible.[7]

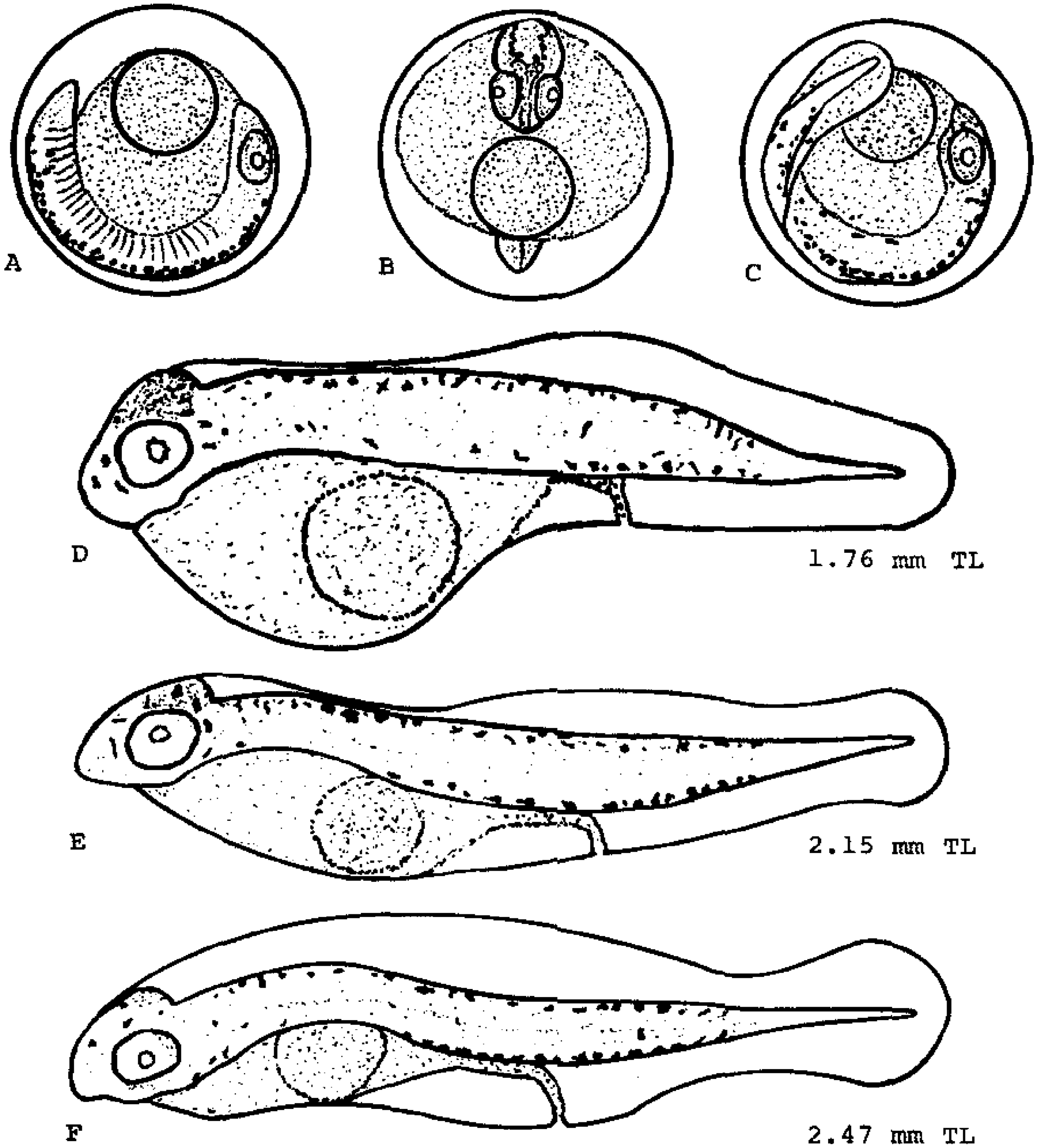

Fig. 33. ***Mugil curema,*** White mullet. A. Lateral view of tail-free embryo, 24 somites present, 24 hours post-fertilization. B. Top view of same embryo. C. Late embryo, finfold present, 32 hours post-fertilization. D. Yolk-sac larva recently hatched, 1.76 mm TL. E. Yolk-sac larva, 4 hours after hatching, 2.15 mm TL. F. Yolk-sac larva, 16 hours after hatching, 2.47 mm TL. *(A-F, Anderson, W. W., 1957: figs. 2–5.)*

Pigmentation: At hatching dorsal and ventral rows of melanophores present, with a few scattered melanophores on sides of head and body. Pigmentation essentially the same after 4 hours (av. 1.89 mm TL), 16 hours (av. 2.36 mm TL) and 32 hours (av. 2.56 mm TL). Eyes pigmented in the 2.56 mm TL specimen with developed mouth and pectoral fins, otherwise pigmentation similar to that of hatchlings.[2]

LARVAE

Specimens described 3.7 mm TL–7.0 mm SL (ca. 8.6 mm TL).[2] Size at end of stage 7.0–7.2 mm SL (ca. 8.6–8.9 mm TL).[1,2]

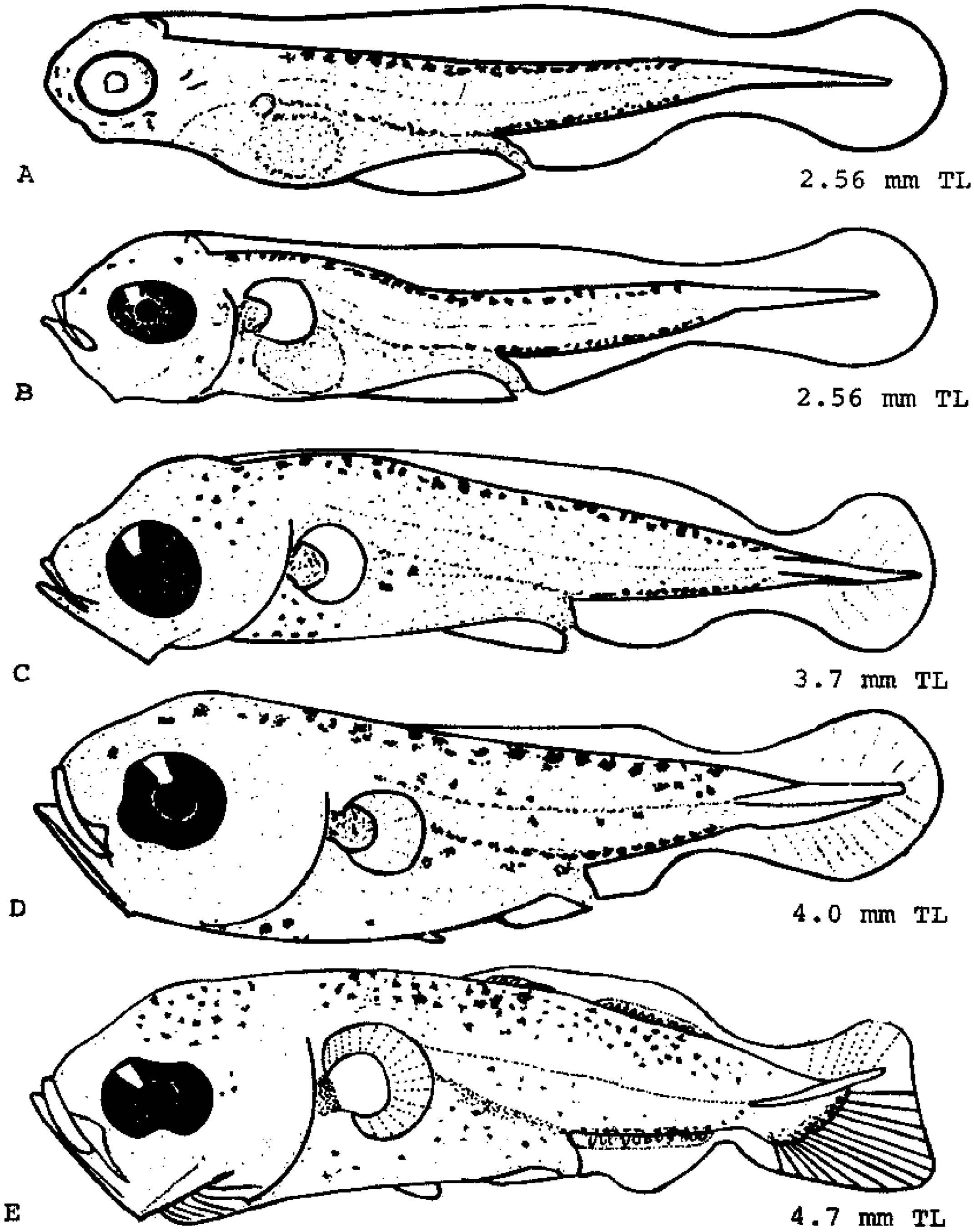

Fig. 34. *Mugil curema,* White mullet. A. Yolk-sac larva, 2.56 mm TL. B. Yolk-sac larva, 2.56 mm TL. C. Larva, 3.7 mm TL. D. Larva, 4.0 mm TL. E. Larva, 4.7 mm TL. (*A-E, Anderson, W. W., 1957: figs. 6–10.*)

Caudal rays formed first, the 14 principal rays countable at 4.7 mm TL; 23 rays at 5.3 mm TL; 25 or 26 at 8.6 mm TL (7.0 mm SL). *Bases of first and second dorsal* fins evident at 4.7 mm TL; first dorsal with 4 spines, second dorsal with 1 spine and 8 soft rays at 5.3 mm TL. Anal bases evident at 4.7 mm TL; full complement of 12 *elements countable at* 5.3 *mm TL. First* pectoral rays developed at about 5.3 mm TL (5–6 rays countable); increasing to about 10 rays by 8.6 mm TL (7.0 mm SL). Pelvic buds developed by 4.0 mm TL; rays evident at 8.6 mm TL (7.0 mm SL).[2] Flexion of the urostyle occurring between 4.0 and 5.3 mm TL;[2] ossification of *hypurals and segmentation of the vertebral column* occurring after 6 mm SL;[4] finfold constricted in the region of the caudal peduncle at 3.7 mm TL, gone from between the median fins at 5.3 mm TL.[2]

Pigmentation: At 3.7 mm consisting essentially of pigment spots along the dorsal and ventral aspects, with scattered melanophores on the head, sides of body, and throat. Development beyond this stage a process of

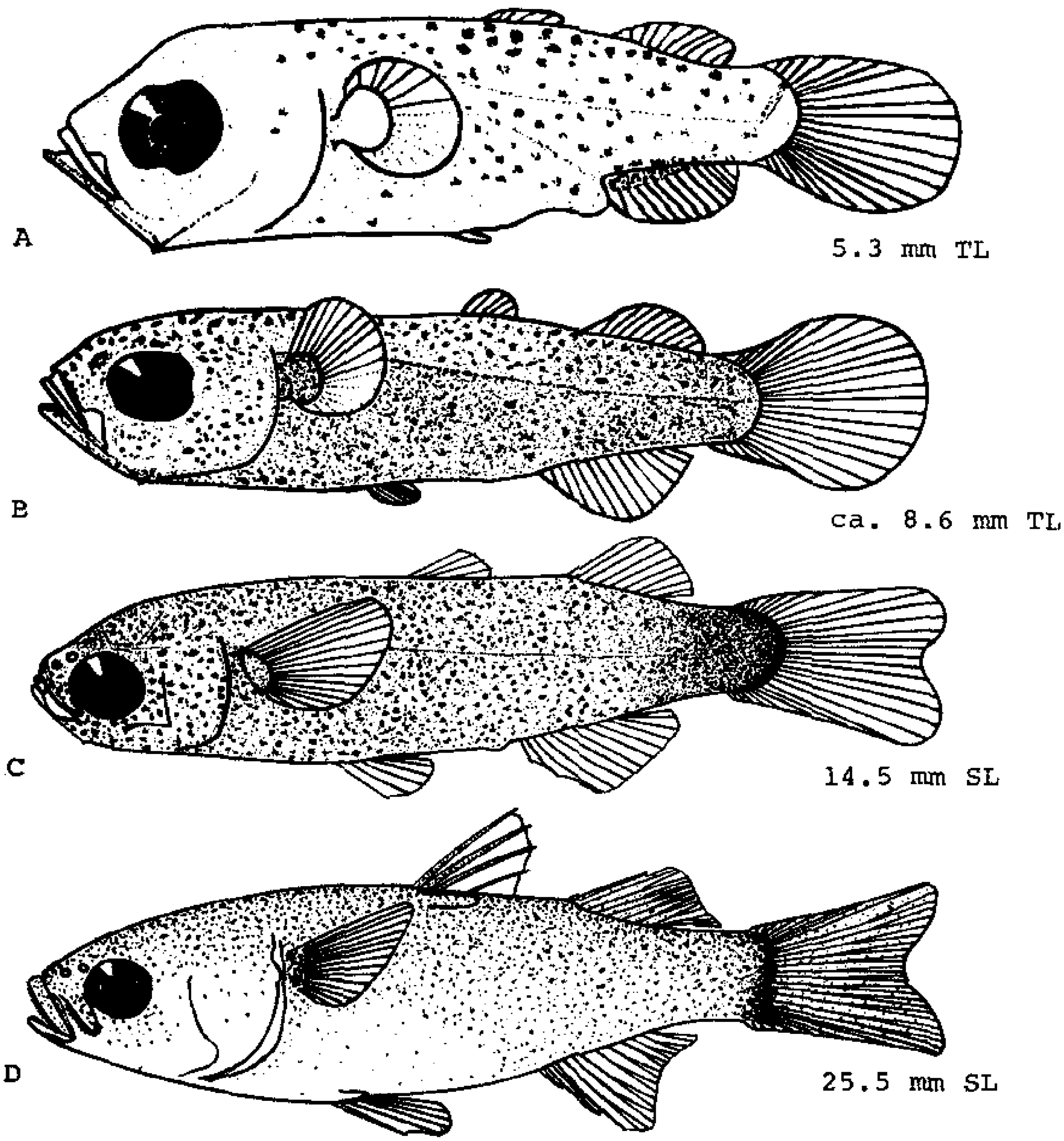

Fig. 85. *Mugil curema,* White mullet. A. Larva, 5.3 mm TL. B. Larva, ca. 8.6 mm TL (7.0 mm SL). C. Prejuvenile, 14.5 mm SL. D. Prejuvenile, 25.5 mm SL. (*A-D, Anderson, W. W., 1957: figs. 11–14.*)

intensification and spreading onto the head and sides of the body. No pigment present on any of the fins during stage.[2]

PREJUVENILES

Size range: Ca. 7.2–40 mm SL (8.9–50 mm TL). Specimens described 7.2–27.2 mm SL.[2]

Modal counts: D. IV, I, 8; A. II, 10, *changing to* III, 9 at end of stage; C. 29, principal rays 14, secondary rays 15; P. 15–17; V. I, 5.[2] Number of elements established by 7.2 mm SL.[1] Scale rows 38 longitudinal, 12 transverse;[22] primary teeth of upper jaw 12–15 at ca. 20 mm SL, 30–35 *at ca. 30 mm SL; primary teeth of lower jaw* none at ca. 20 mm SL, about 30 at ca. 30 mm SL; secondary teeth undeveloped throughout stage.[2]

Scales formed at 7.2 mm SL;[1] prejuvenile scales distinct in form from those of juveniles.[18] At 7.2 mm SL each *nostril pinching in midway along its length, becoming* a double nostril by 9.8 mm SL. Preorbital bone evident at 9.8 mm SL, lacking serrations; subsequent wide variation in size and number of preorbital serrations.[1] Last anal and soft dorsal rays branched by 14.5 mm SL; at *25 mm SL last 7 soft dorsal rays, last 9 anal rays and 12* principal caudal rays branched (1 dorsal ray branching later). Forking of the caudal fin begun by 14.5 mm SL.[2] Soft dorsal and anal fins without a covering of fine scales at less than 30 mm SL.[35]

Pigmentation: At 14.5 mm SL so densely covered by

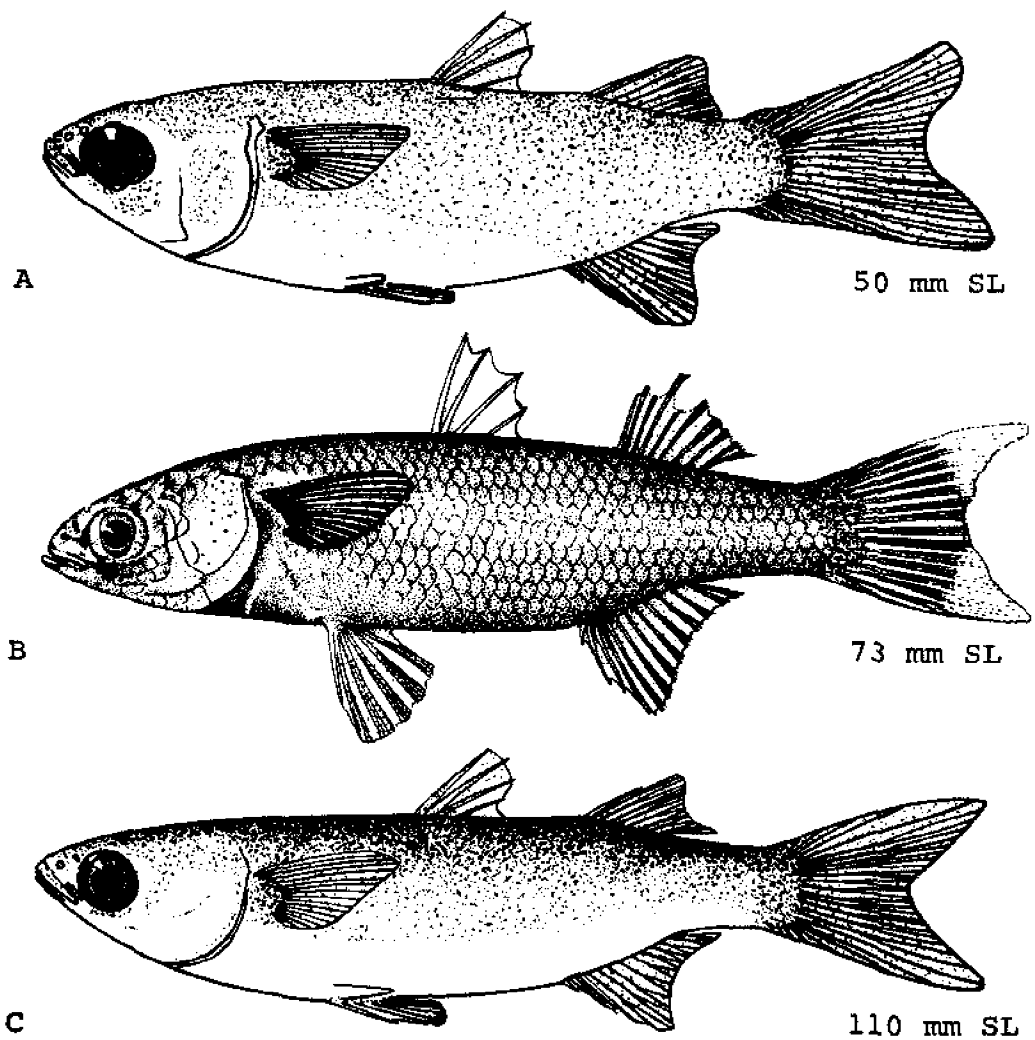

Fig. 36. *Mugil curema,* White mullet. A. Juvenile, 50 mm SL. B. Juvenile, 73 mm SL. C. Juvenile, 110 mm SL. (*A, C, Anderson, W. W., 1957: figs. 15, 16. B, Poll, M., 1959: fig. 88.*)

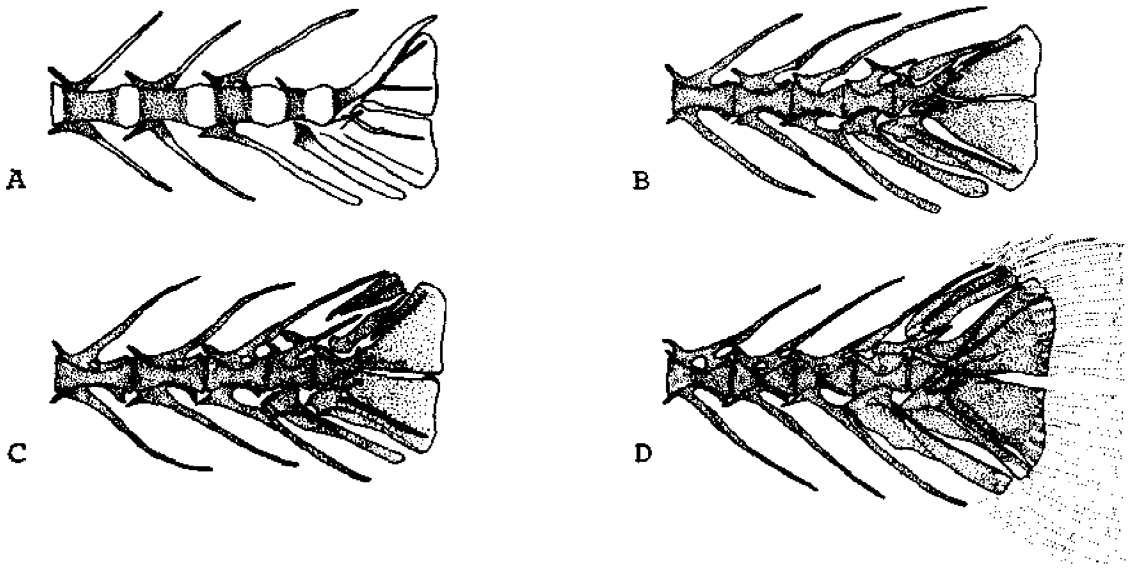

Fig. 37. *Mugil curema,* White mullet. Development of caudal skeleton. A. Tail of 6 mm SL specimen, only slightly ossified, x 36.6. B. Tail of 10 mm SL specimen, only partially ossified, x 26.9. C. Tail of 12 mm SL specimen, still partially ossified, x 21.6. D. Tail of 70 mm SL specimen, fin ray bases represented by dotted lines, representative of all larger sizes, x 4.4. *(A-D, Hollister, G., 1937: figs. 8–11.)*

large and small pigment spots as to appear almost black (this especially intense on the caudal peduncle); no pigment present on any of the fins. At 25 mm SL pigmentation has decreased in intensity; specimens with a peppered appearance, lighter pigmented areas appearing on lower part of the head and belly, and a scattering of pigment spots on the dorsal and caudal fins.[2] At 37–39 mm TL color very dark above, silvery elsewhere; gill covers brilliantly silvery, not translucent; caudal base with a dark bar; snout and margins of lower jaw black; pelvic and anal fins pale, other fins more or less dusky.[37] Jacot's (1920) statement that the species lacks a definite silvery stage [2,18] may refer to the absence of a sharp transition to dusky juvenile coloration such as he described for *M. cephalus* (GED).

JUVENILES

Size ranges from 30–40 mm SL [2,18] to ca. 166–174 mm SL (195–205 mm FL).[27] Specimens described 50–110 mm SL.

Fins and scales same as adult.[2,18] Primary teeth in upper jaw 21–30 at 29–57 mm SL, 24–36 at 68–103 mm SL, 28–48 at 108–172 mm SL; primary teeth in lower jaw 21–42, 28–51 and 41–73 respectively for same size ranges; upper secondary teeth 0–1, 7–40, and 11–60 for same ranges.[2,11]

Caudal fin achieving adult shape by 110.0 mm SL; all 8 dorsal soft rays branched by 50 mm SL; final dorsal shape reached between 50 and 110 mm SL; third anal ray changing to a spine at beginning of stage; final anal shape reached between 50 and 110 mm SL; [2] pectoral tips often reaching level of first dorsal origin in juveniles, unlike adults.[38] Scales exhibiting a sharp transition from prejuvenile to juvenile patterns, subsequently remaining distinctive from prejuveniles and all *M. cephalus* stages in that circuli of posterior exposed region meet anterior circuli at an angle.[18] Few or none of the characteristic small, covering scales on soft dorsal and anal fins before 80 mm SL.[38] By 50 mm SL tips of upper primary teeth flattened and bent sharply inward.[2]

Pigmentation: At 50 mm SL pigment spots on belly so reduced that it begins to appear white; pigment present on anal fin. At 110 mm SL heavily pigmented on dorsal surface above midline, where intensity of color decreases rapidly; lower third of body from head to caudal fin silvery or white; head pigmentation largely on dorsal surface but pigment patches present under eyes and on opercles; all fins pigmented; in freshly preserved material dorsum blue-black grading to silvery white belly.[2]

GROWTH

Estimated at 17 mm SL per month during first year; stragglers spawned in fall could be expected to reach ca. 70 mm SL by December. Non-isometric patterns in body proportions (eye diameter, body depth, head length) affect mostly prejuvenile size classes, growth isometric after 30 mm SL.[2]

AGE AND SIZE AT MATURITY

May mature at one year of age.[2] No fish mature at 195 mm FL (ca. 166 mm SL) in one study,[27] males may mature as small as 86 mm SL and females at 90 or 120 mm SL in Texas (RMH); 75% mature at 225 mm FL (ca. 192 mm SL); all mature after 295 mm FL (ca. 251 mm SL).[27] In a spawning school running ripe males averaged 189 mm SL, females 209 mm SL.[2]

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Membras martinica
Menidia beryllina
Menidia menidia

silversides
Atherinidae

FAMILY ATHERINIDAE

This family is world-wide in distribution, consisting of about 39 genera and more than 150 species. The majority of species are tropical. Most species are small in size, schooling in habit, often very abundant locally, and distributed in close connection with the surface waters of coastal shorelines or secondarily in freshwater (Jordan and Hubbs, 1919; Schultz, 1948). The temperate Atlantic region of North America has three genera, *Menidia*, *Membras* and *Labidesthes*, the latter confined strictly to freshwater and not included in the species accounts below.

Eggs of the three genera mentioned are characterized by the presence of one to several very long adhesive filaments, all attached in a small area of the chorion surface, the number ranging from one in *Labidesthes* and one or a few in *Membras* to many in various species of *Menidia* (Hubbs and Raney, 1946; Wang, 1974). Atherinid larvae are generally recognizable to family by their extreme slenderness coupled with the forward position of the anus; in yolk-sac larvae the preanal length is seldom more than about one-fourth of the total length.

Systematic opinion has varied on the level of relationship between *Menidia* and *Membras*, but they are quite similar in appearance and habits. The mouth is not produced into a beak as in *Labidesthes*. The large, deeply lacinate scales of *Membras*, which are rough to the touch, provide the surest means of distinguishing adults of the two genera. Posterior margins of the scales are entire and smooth in *Menidia*. In both genera the head is scaled, the mouth small and oblique, a wide silver band extends on the sides from the pectoral fin insertion to the caudal fin base, and the first dorsal fin origin is near or behind the midpoint between snout tip and caudal fin base, but anterior to or over the anal fin origin.

Literature on development and systematics of this family is inadequate and scattered. Several of the primary sources used in preparing these accounts are not generally available in published form. In particular, the doctoral thesis of T. W. Robbins (1969) and an unpublished paper by C. A. Kolba (1972) are based on large samples of all three species, and have been cited by others for their contribution of descriptive, meristic and morphometric information.

Some of the terminology and conclusions of Robbins (1969) need introductory explanation. He recognized two lateral line series in these genera, in addition to accessory series not considered here. He defined the more dorsal of the two as the branchial lateral line, which contains pored or otherwise innervated scales only anterior to the pectoral fin tip and on the posterior part of the caudal peduncle. On the basis of nerve patterns this series was considered to correspond to the lateral line of most teleosts. In these forms, however, a more ventrally located postpectoral series contains a greater percentage of innervated scales, the innervation being essentially complete in *Menidia menidia* (Linnaeus), one of the three mid-Atlantic species. Since either series may have been counted by earlier workers, both of Robbins' counts are used below.

Robbins (1969) also concluded that the nomenclature of *Membras martinica* (Valenciennes) should not be considered as stabilized until further study is made of the types. Generic and specific designations of the species depend on the real identity of these types, whose locality (Guadaloupe, West Indies) is seldom listed in the range of the genus as now understood. On the basis of information given by Jordan and Hubbs (1919) and Schultz (1948), Robbins made several points not concurrent with the conclusions of Schultz and supported a premise that the valid name for the species is probably *Kirtlandia vagrans* (Goode and Bean). Subspecific distinction of Atlantic and Gulf coastal stocks was not supported in Robbins' conclusions, although his tables of regional meristic variation show that reduced anal ray counts in the Gulf of Mexico are accompanied by a slight increase in number of soft dorsal rays. This difference is reflected in regional mean values computed from his data, weighting his means from each specific locality by the sample size at that locality.

At the time of this writing, systematics of *Menidia beryllina* have been placed in a state of some confusion by the findings of Johnson (1974, 1975). However, it must be noted that this has had no direct effect on the taxonomy of the mid-Atlantic form. In question are relationships of the nominal forms *M. beryllina* (Cope), *M. audens* (Hay), *M. peninsulae* (Goode and Bean) and *M. peninsulae atrimentis* Kendall, which has been called *M. beryllina atrimentis* Kendall by Carr (1936). Hubbs and Raney (1946) suggested the existence of a *beryllina* species complex involving these forms. Jordan and Hubbs (1919) followed Nichols (1911) in considering *M. audens* a subspecies of *M. beryllina*. Although specific validity of *audens* has been accepted by others before and since, and *peninsulae* has been considered at most a *beryllina* subspecies, including *atrimentis*, studies of Johnson support the earlier opinions of Nichols, Jordan, Hubbs and Raney. In brief, Johnson's major points are: (1) in contrast to the morphological distinctiveness of *audens*, mapping of diagnostic protein alleles reveals an isolated genetic unit identified as *peninsulae*, while *audens* and "*beryllina*" are genetically connected in Louisiana by morphological and biochemically intermediate stocks, (2) the range of *peninsulae* is from eastern Florida to eastern Mexico along the coast, in high salinity waters, (3) in the same geographic range low salinity stocks, termed "Gulf *beryllina*," are genetically close to both *audens* and Atlantic *beryllina*, but somewhat more similar to *audens* (1975, p. 673), Atlantic *beryllina* also being more similar to *audens* than to its gulf counterpart (pp. 673, 685), (4) the hybridization with *Menidia menidia* reported by Hubbs and Raney (1946) and Gosline (1948) involves the ecologically similar *peninsulae* and does not involve low salinity genetic stocks in Florida.

Taken at face value, the above findings complicate preparation of a species account for Atlantic *M. beryllina* in several ways. Developmental information is available for *audens* and contributes usefully if *audens* is to be regarded as a *beryllina* subspecies. Clark Hubbs and Michael S. Johnson (pers. comm.) both agree that incorporation of this data, with the label "*audens*," is warranted. The possibility that two non-interbreeding populations coexist along the coast from eastern Florida to Mexico should be considered in interpretation of all data from that region, and is acknowledged here by separation of such information with the label "Gulf." Except as labeled, data on *M. beryllina* are drawn from the Atlantic coast from Massachusetts to Georgia.

The only systematic question raised in relation to *Menidia menidia* is whether northern and southern subspecies are recognizable. Robbins (1969) concurred with earlier workers that they are not. The figure for that species illustrates the extremes of north-south variation, but Kendall (1902), Robbins (1969) and recently Morgan and Ulanowicz (1976) have concurred that genetic exchange and recombination exist throughout the range, and that mid-Atlantic and particularly Chesapeake Bay forms are intergrades between the extremes.

Problems in interpreting the developmental data available for these species are all related to the scarcity of good figures and the fragmentary nature of existing accounts. Inconsistencies must be acknowledged when figures and accounts by different authors are compared. Kuntz (1916), Kuntz and Radcliffe (1917) and Hildebrand (1922) may have all measured larvae only approximately, or loosely used the term "recently hatched." Alternatively, regional variation may account for most of the length discrepancies. One stated length that must be regarded as doubtful is Hildebrand's (1922) fig. 94 (see fig. 51 E). Kolba (1972) reported finding no *Menidia menidia* with scales at lengths of 16.1 mm SL or less, and Rubinoff and Shaw (1960) could count anal rays in only about a third of specimens ranging from 9 to 15 mm SL, so a length of 13 mm TL for a specimen that appears to be a young juvenile with fin rays and scales fully formed is dubious, and the length of 10 mm TL applied to the same figure by Hildebrand and Schroeder (1928) appears out of the question. The length of one other figure (fig. 104) in the latter work was also misstated, and fig. 109 for *Menidia beryllina* was reproduced in inverted position. Finally, the figures of Wang (1974) for larval *Menidia beryllina* are reproduced with some reservations; even approximate myomere counts on the figures are too high for that species, which should have a maximum count of about 39 myomeres.

Membras martinica (Valenciennes), Rough silverside

ADULTS

D. II to VII (mode IV)-I, 6–9 [2,8] (Atlantic coast $\bar{x}$ 7.23, Gulf coast $\bar{x}$ 7.57); [8] A. I, 15–23 [2,8] (Chesapeake Bay $\bar{x}$ 19.87,[2] Atlantic coast $\bar{x}$ 19.27, Gulf coast $\bar{x}$ 17.45,[8] composite $\bar{x}$ 18.61, composite N=726); C. 17 principal rays [23] *(7–8+9+8+8–10);* [30] P. *11* [2]*–15* [8] *(mode 13);* [2,8] *V. I, 5;* [18,23] branchial lateral line scales 42–50 (usually 45–47), 0–14 innervated; postpectoral lateral line scales 38–45 (usually 40–43), 31–39 in innervated series; predorsal scales 20–26; [8] vertebrae 40–44 (usually 42–43),[8,30] 18–20 *precaudal plus 23–25 caudal;* [30,35] *jaw teeth numerous;* gills 4; [36] branchiostegals 6.[23]

Proportions as percent of SL (N=39,[2] 84 [8]): head 20.9–22.9 ($\bar{x}$ 21.9); [2] snout 5.1–7.3 ($\bar{x}$ 6.1,[8] 6.4 [2]); eye 5.7 [8]–7.6 [2] ($\bar{x}$ 6.7 [2,8]); interorbital 6.7–7.9 ($\bar{x}$ 7.2); depth at origin of first dorsal 16.2–18.18 ($\bar{x}$ 17.5); [2] predorsal 56–63 [8] ($\bar{x}$ 59.4 [2,8]); preanal 57.8 [2]–66 [8] ($\bar{x}$ 60.7,[2] 62.0 [8]); prepectoral 21.0–23.6 ($\bar{x}$ 22.3); pectoral length 18.6–23.9 [2] ($\bar{x}$ 21.0 [2,8]) pelvic length 9.2–11.8 ($\bar{x}$ 10.1).[8]

Body elongate, compressed slightly, depressed dorsally, rounded dorsolaterally, belly compressed, almost keel-like; [8] caudal peduncle rather strongly compressed,[26] rounded dorsolaterally and ventrolaterally, shorter than pectoral fins; dorsal profile sloping gradually upward from snout tip to occiput, almost horizontal to second dorsal origin, sloping gradually downward to caudal base; ventral profile convex from mandibular articulation to pelvic origin, horizontal to anal origin, sloping moderately upward to caudal base.[8] Head depressed above, compressed below; snout pointed; [26] orbits widely spaced, interorbital width greater than eye diameter; eyes moderate in size; head truncate in dorsal view, snout usually blunter in males than females but not diagnostically so as in *Menidia;* snout rugose with sensory pits interspersed among skin folds,[8] four bell-shaped glandular depressions between the nares.[8,35] Mouth very oblique,[46] small, maxillary ending at a point midway between snout tip and eye, its posterior end completely sheathed under lachrymal; gape moderately arched; jaws equal anteriorly; lower jaw narrow,[8] included,[26] not meeting upper jaw laterally; rami of mandibles enlarged and bluntly triangular; mandibular articulation entering sharply in *ventral profile of head; premaxillaries extremely* protractile, their ascending processes narrow and spine-like; premaxillary and dentary toothed; jaw teeth small, pointed, in poorly defined bands or cardiform patches,[8] outer series somewhat enlarged; [26] mandibular teeth not extending on lateral edge of lower jaw.[8] Gill membranes separate, free from isthmus,[36] pseudobranchiae present.[26] Scales large, thick, strongly embedded and arranged in clearly defined rows, their posterior edges lacinate, deeply so in adults and most strongly on dorsum,[8] distinctly rough to the touch; [26] circuli poorly developed on exposed fields; [2,8] apical radii obsolete.[34] Innervation of branchial and postpectoral lateral lines discontinuous and poorly defined.[8] First dorsal fin very small,[36] its origin over the anus and much closer to caudal fin base than to snout tip; all dorsal spines except the first about the same length, the first shorter; second dorsal origin over the ninth or tenth anal ray,[8] its base over the posterior half of the anal fin, the two fins nearly coterminal; caudal fin moderately forked; [26] anal fin somewhat falcate; pectoral fins long, extending to or past the pelvic fin insertion,[36] pointed, their upper rays longest; [26] pelvic fins short.[8,26] Second dorsal and anal fins sheathed at bases with ovately shaped scales; [8,34,35,36] axillary scales well developed,[8] pelvic fin bases with an enlarged scale between them and one on either side.[36] Air bladder rounded posteriorly, reaching a point between anus and the anal fin origin.[8,35]

Pigmentation: Clear, translucent greenish above,[36] silvery on lower sides and belly,[26] sides with a wide silver band (stole) from dorsal insertion of pectoral fin to caudal fin base, its width uniform except for a slightly narrowed portion below the posterior end of the second dorsal fin base; [8] stole bounded above by a dark line; [26] only dark pigmentation below stole along the base of the anal fin and light spotting ventrally on caudal peduncle; scale pockets above stole not outlined with melanophores, instead pigment concentrated near scale centers,[8] appearing in dorsal view as rows of black spots [2,36] or streaks from nape to caudal fin; [8] occipital region often bluish or dusky; [26] snout dusky from tip to posterior edge of four glandular depressions, except pigment lacking in membranous area between premaxillary processes,[8] this area yellowish in life; [36] intermandibular pigment variable, usually restricted to scattered melanophores on anterior portion; dorsal fin rays lightly spotted to fin tip,[8] caudal yellowish with a dusky edge,[26] caudal rays punctuated with evenly distributed melanophores; anal fin clear except for a concentration of melanophores at the base; upper five or six pectoral rays lightly spotted for about half their length; pelvic fins clear.[8]

Maximum size: 113 mm SL (Mississippi); [14] largest Maryland specimen about 102 mm TL.[1]

DISTRIBUTION AND ECOLOGY

Range: Atlantic and Gulf coasts from Great Peconic Bay, New York [22] to Rio Panuco, Mexico,[34] and the type locality Martinique (known there only from the types).[8]

Area distribution: From numerous localities in the area, seldom collected consistently in spite of its wide distribution;[8] common in southern Chesapeake Bay, rare in the northern sections; entering streams, but less commonly than *Menidia menidia*;[26] adults in summer reported from the eastern halves of two Maryland seaside bays.[3]

Habitat and movements: Adults—in open[24] and shallow[6,8,9,24,33] water; not a marsh species, usually along exposed shorelines[10,11] and beaches[4,5,6] with little vegetation[8] over bottoms composed of sand,[4,6,31] gravel,[31] shell or firm mud.[6] Salinity range from freshwater[12,20] to about 37 ppt[12,36] (1 specimen at 40.3 ppt[25]), more often at higher salinities than *Menidia*.[8,16] Temperature range 9.4[33] to 34.9 C[14,33] (36.5 C in a thermal discharge area[9]). Usually schooling near the surface[9,24] from shallow flats[6,9,24,33] to water 3–6 m deep.[13,24] Upstream occurrences concentrated in summer and early fall;[7,12,29,31] evidence of an offshore exodus with onset of lower temperatures;[6] rare or absent in bay and beach collections in January and February,[6,9,14,24,33] while schooling adults taken at surface a short distance offshore in fall and winter.[3]

Larvae—little information, probably not separated from *Menidia* larvae in earlier studies; taken from surface to bottom in Chesapeake and Delaware Canal.[28]

Juveniles—habitat not differentiated from that of adults in most reports; all fish of this species at lowest salinities were small;[6] salinity range 0–15 ppt,[17] 13–28 ppt;[19] temperature range 14[17]–32.7 C;[19] swimming in large schools near the surface.[15]

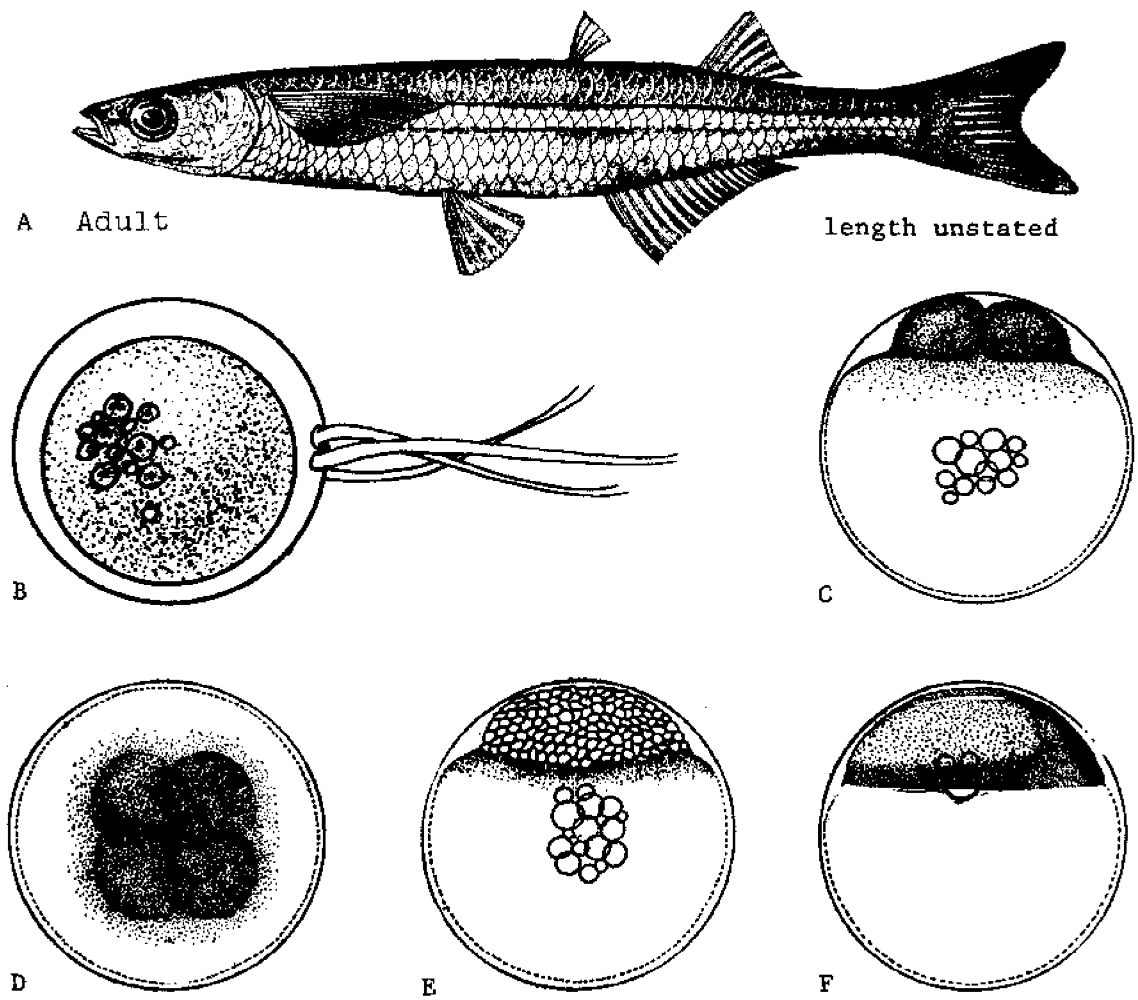

Fig. 38. ***Membras martinica***, **Rough silverside. A. Adult, length unstated. Scale lacinations not indicated in this figure. B. Egg (diagrammatic), only bases of filaments shown. C. Egg, 2-cell stage. D. Egg, 4-cell stage. E. Morula stage. F. Egg, germ ring stage (early gastrula).** *(A, Jordan, D. S., 1905: fig. 171. B, Wang, J. C. S., 1974: 143. C-F, Kuntz, A., 1916: figs. 32–35.)*

SPAWNING

Location: Just outside the breaker zone on sandy beaches (TWR).

Season: Ripe May to late July or early August in Chesapeake Bay and North Carolina,[13,21,26,27] small young *present June to August*[28] *or September;*[17] *ripe on the* Gulf coast between March and August[6,14,19,24] or September,[14] a lull in ripening between May and July,[19] bimodality of juvenile size distribution tending to confirm this (GED).

Temperature: Ripe in range 21.2–30.7 C.[19,24]

Salinity: Ripe in range 9.4–31.1 ppt;[19,21] spawning at 5–25 ppt.[21]

Fecundity: No information.

EGGS

Location: Demersal; adhering together in clusters; carried inshore to intertidal zone in large clusters wave action (TWR).

Unfertilized eggs: Spherical, slightly yellowish, almost transparent; micropyle relatively small.[27]

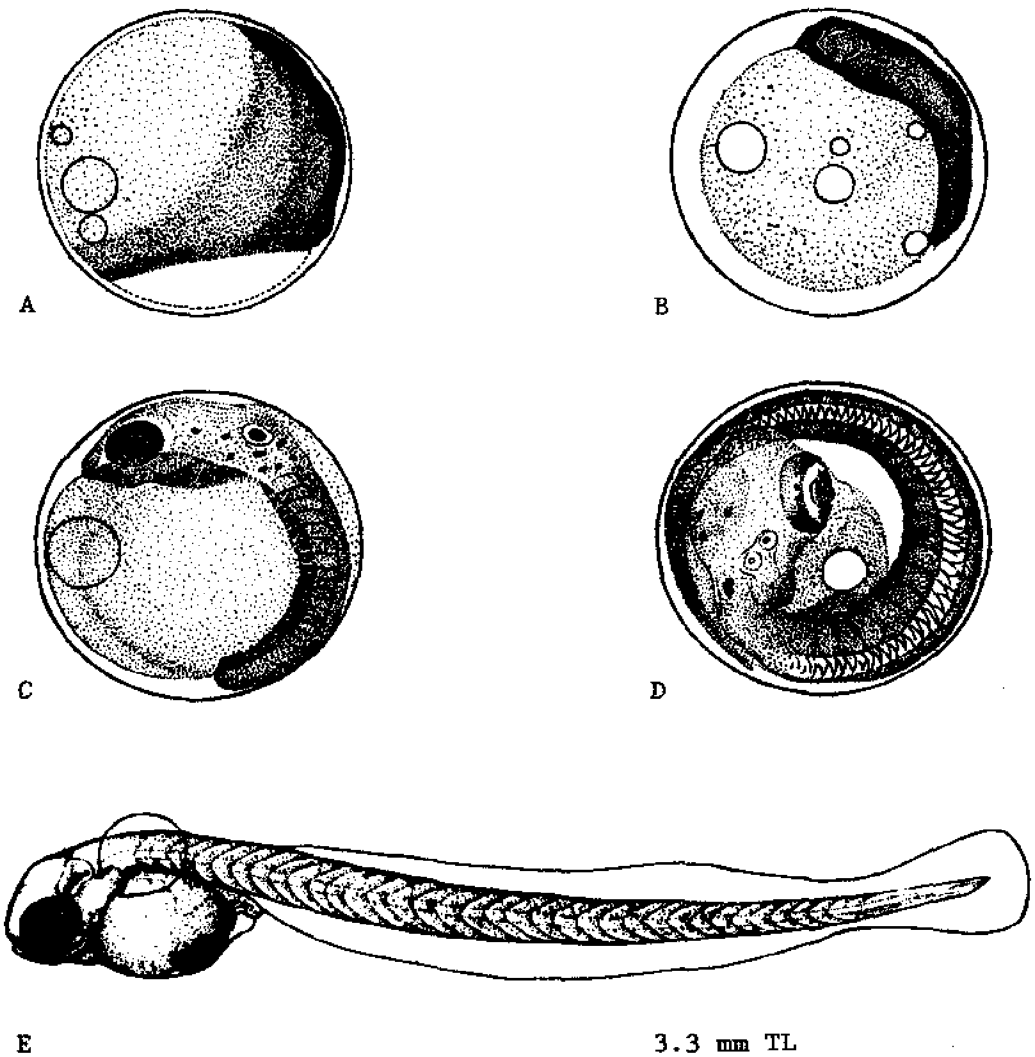

Fig. 39. *Membras martinica*, Rough silverside. A. Neural crest stage (late gastrula). B. Embryo, optic vesicles formed, somites forming. C. 40-hour embryo, note oil droplets have coalesced. D. Egg just before hatching. E. Yolk-sac larva, 3.3 mm TL. (*A-D, Kuntz, A.. 1916: figs. 36–39. E, Wang, J. C. S., 1974: 146, rephotographed, with permission, from an original drawing by R. Lynn Moran.*)

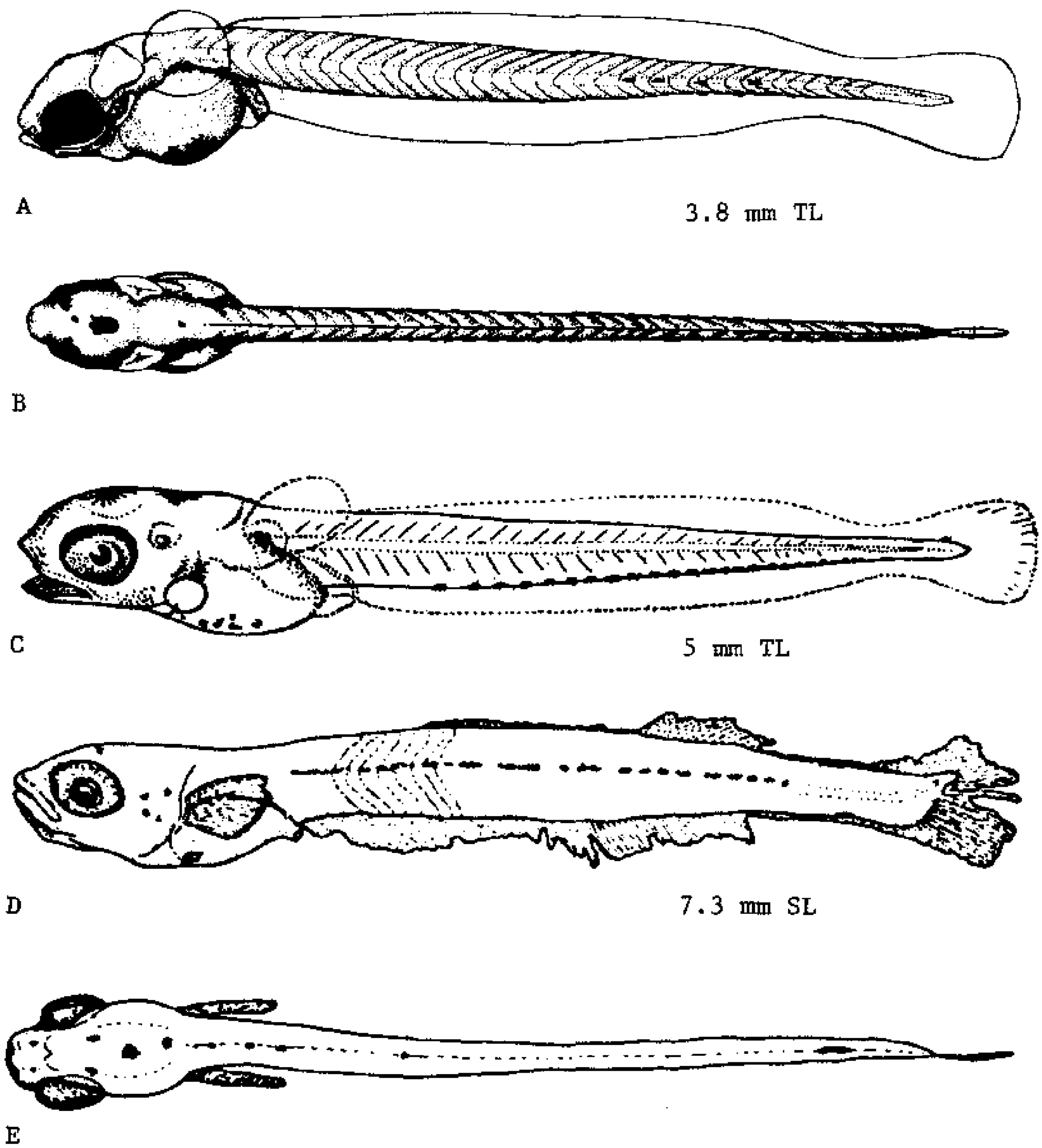

Fig. 40. *Membras martinica*, Rough silverside. A. Yolk-sac larva, 3.8 mm TL. B. Dorsal view of same. C. Yolk-sac larva, 5 mm TL. D. Larva, 7.3 mm SL. E. Dorsal view of same. (*A, B, Wang, J. C. S., 1974: 146, re-photographed, with permission, from an original drawing by R. Lynn Moran. C, Kuntz, A., 1916: fig. 40. D, E, Kolba, C., 1972: figs. 4A–4B.*)

Fertilized eggs: Shape and color as above; egg diameter 0.7–0.8 mm,[21] 0.8–1.0 mm. 8–15 oil globules of unequal and varying size at the upper pole in early stages of development; a narrow perivitelline space present;[27] a small tuft of 1–3[21] enlarged, adhesive filaments arising from the chorion which serve as an attachment mechanism,[21,27] filaments coarser and less numerous than those of *Menidia* species.[21]

EGG DEVELOPMENT

Cleavage meroblastic, equal; second cleavage at right angles to first.[27]

Early development in laboratory somewhat more rapid than that of *Cyprinodon variegatus* at similar (also unspecified) temperatures; tail bud stage with established blood circulation reached in 40 hours; oil globules indicated to gradually coalesce into a single larger globule by this stage; and a few melanophores evident posterior to eye and ventral to auditory capsule. In the embryo figured shortly before hatching the only melanophores shown are a few on the dorsal aspect of the head.[27]

Incubation time: 6–7 days at unspecified (summer) laboratory temperature; unspecified salinity.[27]

YOLK-SAC LARVAE

Hatching length: 3.0[21]–5.0 mm TL.[27]

At hatching body slender; snout to vent length close to one-fourth of total length; oil globule shown at anterior end of yolk sac; finfold originating just posterior to the head; dorsal and ventral finfolds continuous; greatest depth of neither portion of finfold exceeding half of body depth at the vent;[21] finfold shown as somewhat constricted posteriorly.[27]

Pigmentation: Highly transparent;[27] one large and a few small melanophores on head;[21] a line of pigment spots along the base of the ventral finfold;[27] a dark patch figured on the ventral surface of yolk sac and a suggestion of dark pigment along the dorsal side of the developing gut;[21] at 5 mm TL ventral dark patch indicated as breaking up.[27]

LARVAE

Specimens described 7 mm TL–11.6 mm SL or 13 mm TL. Size at end of stage not established, but before 20 mm TL.[21]

At 7.3 mm SL (ca. 7.9 mm TL) soft dorsal, anal and principal caudal rays shown as differentiating pectoral rays not indicated, pelvics absent or represented as small buds; urostyle flexion nearly complete.[2] At 9 mm TL body still relatively slender; procurrent caudal rays and

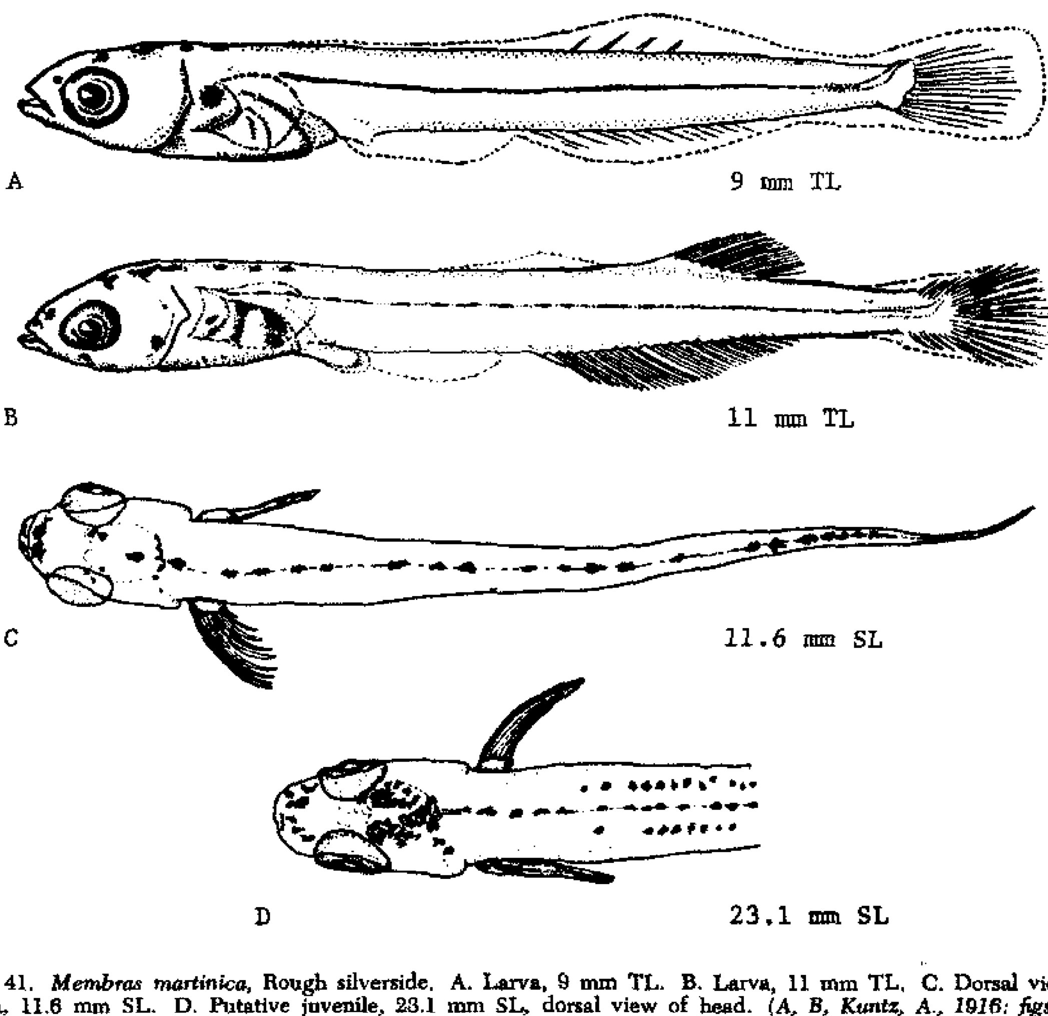

Fig. 41. *Membras martinica*, Rough silverside. A. Larva, 9 mm TL. B. Larva, 11 mm TL. C. Dorsal view of larva, 11.6 mm SL. D. Putative juvenile, 23.1 mm SL, dorsal view of head. *(A, B, Kuntz, A., 1916: figs. 41–42. C-F, Kolba, C., 1972: figs. 4C–4D.)*

first dorsal and pelvic fins still undeveloped. At 11 mm TL procurrent caudal rays differentiated; rays of soft dorsal and anal fins appearing well ossified; first dorsal and pelvic fins still undifferentiated; anus shifting backward, preanal length about one-third of total length.[27] At 11.6 mm SL pectoral rays appearing well ossified in dorsal view.[2]

Pigmentation: At 9 mm TL a few spots on the dorsal aspect of the head, and a dark longitudinal line along the side of the body; the silvery character not yet apparent. At 11 mm TL the sides becoming distinctly silvery, but the pale green on the back, characteristic of the species, not yet apparent.[27] Dorsal surface melanophores, like those of juvelines and adults, arranged in one row down the mid-dorsal line, although in small larvae the row not extending the whole length of the fish. Pigment spots at the base of the anal rays but very rarely found lateral to the anal fin (as in *Menidia*).[2]

JUVENILES

From less than 20 mm TL [21] to 50–63 mm SL.[6,8,19]

The smallest individual observed to possess scales measured 14.1 mm SL (possibly a larva, GED), in it the diagnostic anterior projection appeared as a gradual arc; [2] in individuals 14–30 mm SL scales similar to adults except posterior margins less lacinate; [21] the greatest developmental change in the lateral line occurring between 30 and 40 mm SL.[8]

Pigmentation: Basically similar to adults (GED); the characteristic mid-dorsal row of melanophores very prominent in juveniles less than 30 mm SL.[2]

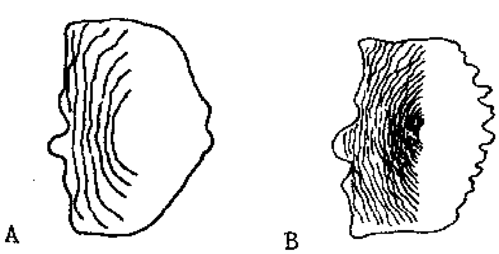

Fig. 42. ***Membras martinica***, **Rough silverside.** A. Scale from lateral stripe of juvenile 23.1 mm SL. B. Scale from lateral stripe of adult 77.8 mm SL. *(A, B, Kolba, C., 1972: figs. 1C–1D.)*

GROWTH

Progression of modes in length-frequency distribution [8,14] indicate growth of ca. 9 mm per month for Gulf coast juveniles in summer.[14]

AGE AND SIZE AT MATURITY

No definitive information on age, a size class averaging 43 mm in June and reaching reproductive size ranges in July were assumed to have been spawned the previous year [14] but may have been spawned in March of the same year [19] making them 4 months old in July. Adult size 50 mm SL,[8] 63 mm SL;[6] gonads immature in individuals less than 49 mm TL.[19]

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Menidia beryllina (Cope), Tidewater silverside

ADULTS

(Atlantic coast form) D. IV to VI (mode V)–I, 7–11 ($\bar{x}$ 9.53);[14] A. I, 13–20 [2,3,14,16] ($\bar{x}$ 16.59 [14]); C. 17 (9+8) principal rays;[55] P. 12–14 (mode 12–13);[3] V. I, 5;[16] branchial lateral line scales 35–43 [6,14] ($\bar{x}$ 38.76), 4–12 innervated; *postpectoral lateral line scales 31–39* (*$\bar{x}$ 35.26*), *26–34 innervated*; predorsal scales 11–18 (mode 16); caudal peduncle scales 10–14 (mode 12);[14] vertebrae 37–40,[2,6,12] 17–19 abdominal plus 19–21 caudal (modes 18+20);[2] jaw teeth numerous; no teeth on vomer or palatines; gills 4.[45] *M. beryllina complex (see Introduction): D. II to* VII–I, 7–11; A. I, 13–22; P. 11–16; lateral line scales 35–48; postpectoral lateral line scales 28–37; predorsal scales 11–24; caudal peduncle scales 28–37; vertebrae 36–41.[14]

Proportions as percent of SL (for Atlantic coast form): Head 23.4–27.4 ($\bar{x}$ 25.0); snout 6.3–8.5 ($\bar{x}$ 7.4); eye 7.2–9.9 ($\bar{x}$ 8.4); interorbital 6.0–8.0 ($\bar{x}$ 6.9);[3] greatest depth 15 [16]–20 [3] ($\bar{x}$ ca. 16.4); predorsal 45.2–55.3 ($\bar{x}$ 51.5);[2,3,6] preanal 54.7–64.3 ($\bar{x}$ 59.6); prepectoral 22.9–26.5 ($\bar{x}$ 24.8); pectoral length 16.5–22.0 ($\bar{x}$ 19.1);[3] pelvic length 9.9–21.0 ($\bar{x}$ 13.0) (includes Gulf).[14] *M. beryllina* complex: Snout 6–9; eye 6–10; predorsal 45–59; preanal 53–65; pectoral length 16–21.[3,14] Weighted means for various nominal populations: Atlantic *beryllina* head 23.2–23.8,[8] predorsal 51.5, preanal 59.6;[3] Gulf *beryllina* head 23.4,[8] predorsal 53.4, preanal 59.0;[7] *peninsulae* head 25.3;[8] predorsal 53.3; preanal 60.5;[7] *audens* head 23.8;[8] predorsal 51.8; preanal 56.4.[7]

Body slender,[16] elongate,[49] moderately compressed, slightly depressed dorsally, rounded dorsolaterally; flanks moderately rounded, not slabsided; belly rounded;[14] caudal peduncle rather long,[16] evenly rounded; dorsal profile rising gradually to first dorsal origin, flat between dorsal origins, declining sharply along second dorsal base, more gradually posteriorly; ventral profile convex anteriorly, nearly horizontal from pelvic origin to anal origin, rising sharply along anal base, more gradually posteriorly.[14] Head somewhat depressed above, narrower below;[16] snout moderately long, blunt to moderately pointed in dorsal and lateral profile (blunter in males); eye large.[14] Mouth rather small, terminal,[16] oblique; jaws usually equal;[14] premaxilla protractile; maxillary not reaching eye;[49] teeth small, pointed,[16] retrorse, in two rows which are distinct anteriorly, less so on posterior third of upper and lower jaws, inner row with slight inward curvature, outer row more anteriorly projected;[14] gill membranes free from isthmus;[45] pseudobranchiae present.[16] Scales cycloid; shield-shaped on caudal peduncle, rounded elsewhere;[14] posterior exposed edges smooth, anterior edges scalloped;[3] circuli usually well developed on all fields; radii best developed on caudal peduncle, less well more anteriorly; anterior scales higher than long, tending to become of equal height and length toward the caudal peduncle. Postpectoral lateral line usually complete, some scales occasionally lacking pores or external neuromasts. Origin of first dorsal fin usually closer to caudal base than to top of snout but well in advance of anal origin; origin of second dorsal fin over seventh to ninth anal ray; anal fin falcate, short,[14] its base equal to or slightly longer than head; caudal moderately forked;[16] pectoral fins moderate in length, pointed; pelvic fins proportionately long, abdominal, inserted midway between dorsal pectoral fin insertion and origin of anal fin.[14] Scales extending somewhat on caudal fin base but not on base of soft dorsal or anal fins.[16] Posterior end of swim bladder extends past anal origin to at least the third anal ray (to sixth or eighth ray in *audens*).[2,7,14]

Pigmentation: Translucent and waxy in appearance (becoming straw colored and opaque in preservation);[8] pale greenish [16] (*beryllina* less green than *peninsulae* [66]), head and lower parts silvery; sides with a well defined silver band narrower than half the eye, bounded above by a thin dark line;[16] a dusky mid-dorsal streak, one also midventrally on caudal peduncle; a splotch of dark pigment before anal fin origin [14] and a dusky streak along base of anal fin;[8] most scale pockets outlined with light to heavy spotting, increasing toward dorsum; snout dusky, covered generally with small melanophores, these concentrated around anterior nares and on dorsal fleshy part of snout;[14] chin dark;[8] opercle may be lightly spotted; light spotting along edges of spines and rays extending to fin tip on pectorals and both dorsal fins, heavy along caudal fin rays, absent or very light on pelvic fins, concentrated between anal rays at base of fin, usually extending along rays to tip of fin but absent along posterior edges of rays when not extending to tip.[14]

Maximum size: 81 mm FL (Delaware),[17] 105 mm FL (North Carolina);[21] females usually less than 72 mm SL, males less than 65 mm SL;[1] 125 mm TL [52] (Gulf); 150 mm (TL?) [22] (*audens*), probably maximum for *M. beryllina* complex (GED).

DISTRIBUTION AND ECOLOGY

Range: Massachusetts to South Carolina [49] and Georgia (see Introduction), distributed from the coast almost to the fall line of coastal creeks and rivers.[21,29,30,3] *M. beryllina* complex: Quincy, Massachusetts to Vera Cruz, Mexico;[2,8,14] to above Laredo, Texas in Rio Grande River (Gulf);[31] Mississippi Valley to Reelfoot Lake, Tennessee, and Red and Arkansas River drainages in Oklahoma (*audens*);[2,14] introduced in several central Texas impoundments (Gulf)[37] and in California (*audens*).[39]

Area distribution: Throughout the Mid-Atlantic Bight in rivers below the fall line, estuaries and upper bays.[5,14,16,29,30,43,54]

Habitat and movements: Adults—tidal river channels, seldom taken in coves;[32] generally not an open beach form;[14] more common over sand and gravel bottoms than over mud[56] but showing little preference in regard to bottom characteristics;[28,34] particularly abundant in the vicinity of submerged vegetation.[14] Gulf populations[44] and *audens*[22] more common over sand than hard or soft bottoms; usually associated with some sort of shelter such as islands, piers, oyster bars or pools containing rubbish;[20] in a Florida lake more often associated with pondweed (Gulf);[27] most abundant over gradually sloping bottoms (*audens*);[22] classified as a lower stream and lake form (*audens*).[46]

More commonly in brackish than salt water; ascending streams into strictly freshwater,[1,16] up to 72 km above the fresh-brackish interface in Virginia, more abundant

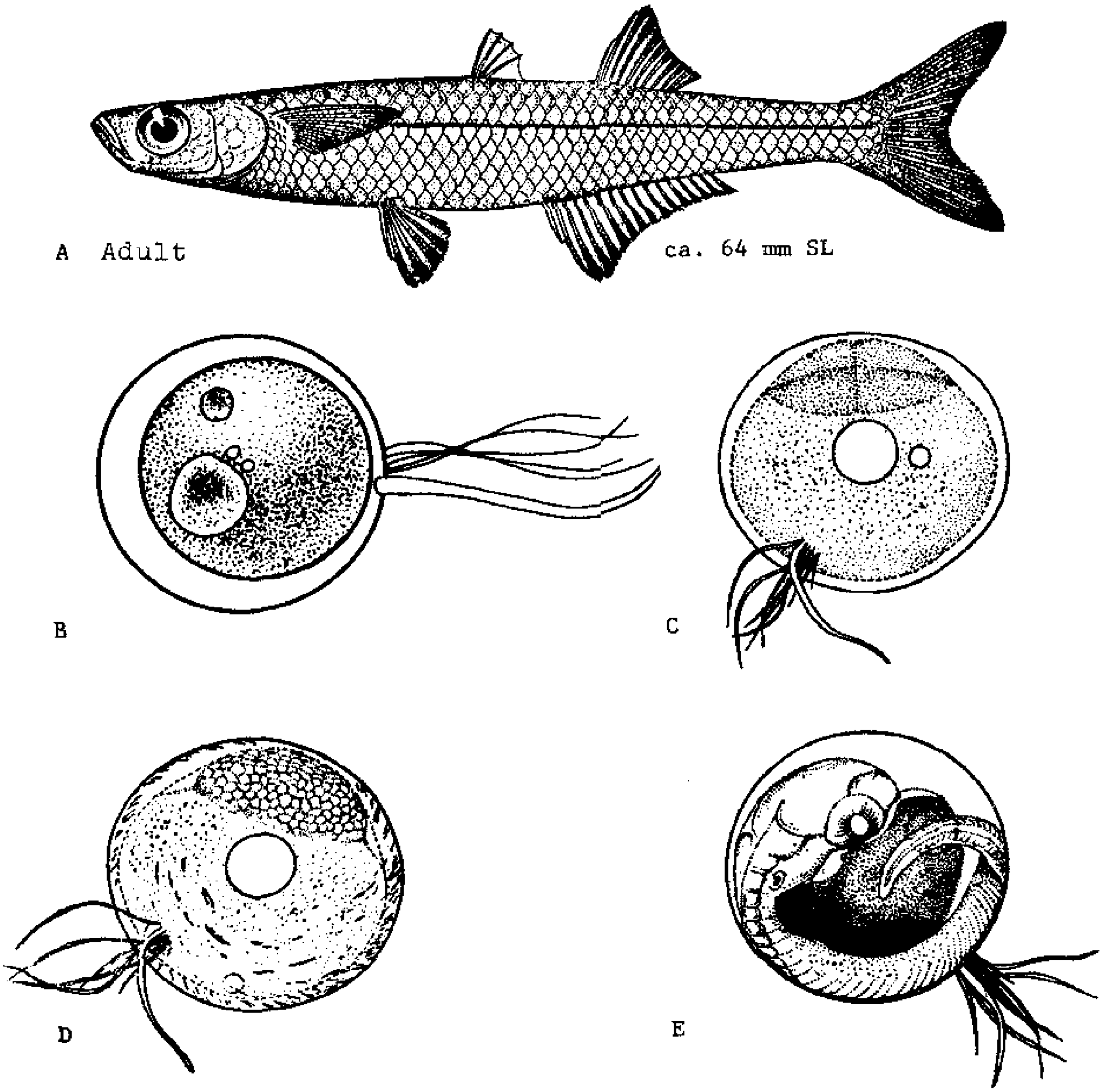

Fig. 43. ***Menidia beryllina***, Tidewater silverside. A. Adult, ca. 64 mm SL. B. Egg (diagrammatic), only bases of filaments shown. C. Egg, 2-cell stage. D. Egg, morula stage. E. Advanced embryo, 2 1/2 days after fertilization. (*A, Kendall, W. C., 1902: 260. B, Wang, J. C. S., 1974: 143. C-E, Hildebrand, S. F., 1922: figs. 95–97.*)

above than below the interface; [29] *salinity range* 0–22.3 ppt (North Carolina),[21] 0 [34]–29 ppt (Delaware),[63] seldom above 26 ppt from June to September (Maryland).[5] On Gulf coast wide salinity tolerance (0–75 ppt) [25,52] and some bimodality of salinity distribution [10,18,26] may reflect presence of two species.[4] Temperature range 2.9 [21]–32.5 C.[56] Gulf range 8.0 [18]–34.0 C [35] (39 C in a thermal discharge population [15]) or minimum 5.0–9.9 C, maximum 30.0–34.9 C; [23,36,51] absent at 35.0 C from one station frequented at lower temperatures (Gulf).[18]

The species seldom taken in deep water; [16] in comparison of seine versus surface trawl catches 97% taken in seine *(67% of M. menidia from seine in same study).*[67] All sizes found in top 30–45 cm of the water column (Gulf); [19] seldom deeper than 2 m (*audens*).[22,59]

Little information available on movements, suggested to winter in deeper parts of the bays,[5] but present at upriver stations in Neuse River, North Carolina every month, absent from downriver stations in winter.[21] Some evidence of winter movement away from shallow, low salinity stations in a Louisiana bay [47] and from smaller streams in Alabama (Gulf).[24]

Larvae—forming large schools in vegetated shallows of fresh and brackish waters,[58] habitat descriptions essentially the same for all size classes.[33,43] Salinity range 0–15 ppt, larval concentrations 2–8 ppt. Temperature range 12–30 C, concentrations 23–28 C. Most common in *surface waters.*[43]

Little evidence concerning larval movements; not collected with *M. menidia* larvae in tidal currents of Massachusetts bays, postulated to lack planktonic dispersal capability of that species at 4–8 mm TL,[67] but small numbers reported from surface, midwater, and bottom *plankton tows in the Chesapeake and Delaware Canal.*[69]

Juveniles—habitat not described as different from that of adults; adult and juvenile schools abundant in shallow water.[33] Salinity range 0–15 ppt, concentrated at 2–8 ppt.[43] A discrete size class of juveniles at Tampa Bay, Florida (Gulf), apparently spawned in early spring, moved in July from lower salinity bayou stations to higher salinity stations in the bay, while a group spawned later remained in the bayou.[9] Temperature 1.8–32.0 C,[21] concentrated in range 21–29 C; [43] ca. 5.0 [23]–33.5 C (Gulf).[12] Depth and movements probably similar to adults (GED).

SPAWNING

Location: In shallows with abundant dead leaves, tree roots [44] and vegetation; [1] primarily in tidal freshwater [44] or brackish water; [58] in upper, middle and lower parts of Potomac estuary,[35] mainly in upper parts of shorter estuaries (based on larval distribution).[33,56] Rooted aquatic plants at depth of 2–15 cm apparently preferred, *maximum depth 90 cm (audens).*[71]

Season: Eggs reported mid-May through August in Delaware,[56] Potomac River [35,44] and Chesapeake and Delaware Canal; [57] ripe or nearly ripe adults most of June and July at Woods Hole, Massachusetts,[6] 10 April to 19 September in Chesapeake Bay,[16] March to September in North Carolina; [1] young (larvae and small juveniles) June to October with July peak in Delaware,[17,56] June through November in Chesapeake Bay [43] and North Carolina.[21] Gulf records include breeding adults in March,[20] April [14] and July,[20] ripe adults [9,13,57] and larvae [11] in every month, some evidence from juvenile size distributions of *discrete spawning pulses, one in early spring, another in* late spring or early summer, and a third in the fall; [9,10,13,15,20,23] *audens* spawning late March or early April through mid-July in Oklahoma, females can produce egg clutches at 6-day intervals.[22]

Time of day: Mid-morning (*audens*).[70]

Temperature: 18–30 C.[56] Spawning (Gulf) observed at 26 C; [14] ripe females (Gulf) at 19–32.7 C; [10,20,50] *audens* spawning observed at 20 C; [71] its spawning (based on egg tolerances) would be reasonably successful in range 17–34 C.[22]

Salinity: Spawning primarily in tidal freshwater.[44,56]

Fecundity: No information except for *audens*, 984 eggs average per female (range 384–1699),[59] may spawn this many at weekly intervals for several weeks.[22]

EGGS

Location: Demersal; [44] adhering to objects on or near bottom; reported substrates including algal filaments,[14,44,56] other vegetation,[1,14,44] debris [44] and the concrete bottom of a spillway sluice.[56]

Fertilized eggs: Not quite spherical when first spawned,[1] some eggs that develop normally remain slightly irregular in shape throughout development (GED); transparent, slightly greenish [1] or *yellowish;* [60] 1 to 3 large oil globules of varying size and a few to several smaller ones; [1,44,60] perivitelline space greatest at pole of germ disc, narrowest opposite this point; [1] chorion with a tuft of 4 [60]–9 [1] adhesive filaments, one filament enlarged and much longer than the others,[1,44] enlarged filament arising among the others or slightly separated,[44] its length about 30 to 50 mm (much longer than figures shown), the measurements inexact because of considerable elasticity; tuft of filaments coiled around egg [78] and nonadhesive when eggs artificially stripped, uncoiled and becoming adhesive a few minutes after fertilization (GED); filaments at first transparent, opaque while uncoiling, later transparent again. Egg diameter less than 0.75 mm (North Carolina),[1] 0.9–1.0 mm (Massachusetts); [60] *audens* 0.9? mm (Oklahoma).[42]

EGG DEVELOPMENT

Cleavage meroblastic, equal; second cleavage at right angles to first.[1]

Development not significantly different from that of *M. menidia*.[1] The following notes on development and embryonic pigmentation from an artificial cross made in the field at Solomons, Maryland, 5 May 1976, development temperature 21.0–22.0 C, examined only at times noted (GED):

Days	*Hours* (to nearest 0.5 hour)	
0	3.0	Between first and second cleavage.
0	16.5	Early blastula.
0	21.0	Late blastula.
2	0	Embryonic shield; no pigment.
2	18.5	Heart formed and beating; melanophores and leucophores present on yolk and body.
3	21.5	Lens vesicles formed, melanophores on medial surface of optic vesicles, on floor of braincase, at posterior junction of trunk and yolk sac, a few scattered on ventral half of caudal trunk, and ca. 60 large dendritic ones on surface of yolk sac, more dense dorsally.
5	1.5	Eye pigment beginning as a light gray shading; pigment little changed otherwise.
6	1.0	Eyes pigmented, color brown; other pigment little changed.
7	2.5	Eyes rust brown; granular leucophores on braincase floor, behind retinas and scattered through flesh of trunk; 3–4 melanophores along furrow between yolk sac and trunk; some still clustered at posterior end of this furrow.
8	2.0	Eyes silver; granular leucophores clustered around optic nerves, pectoral girdle and region of anus, a few still scattered in ventral half of caudal trunk; melanophores unchanged.
9	2.0	Leucophores have become dendritic, same distribution as before; a few melanophores (2–5) have appeared on posterior dorsum of brain.
9	21.5	First hatching. Head melanophores (3–8) dendritic on unhatched embryos (contracted in hatchlings); unhatched embryos with a single oil globule; clusters of leucophores still in pectoral and anal regions but also on surface of caudal trunk; melanophores distributed fairly evenly over yolk sac surface and in a patch over coelomic region between pectoral and anal leucophore clusters.
10	23.5	About half of eggs hatched.
12	2.5	All hatched except a few obviously deformed (these did not hatch).

Incubation time: Hatching days 10, 11 and 12 at 21–22 C (GED), 12 days at 22–29 C (Maryland);[38] days 8, 9 and 10 at 25.6–27.8 C (North Carolina);[1] days 5 and 6 at 29 C,[40] 6 days at 27 C$\pm$0.5 C (Gulf, Texas);[41] from 4 days at 34 C to 30 days at 13 C (*audens*, Oklahoma).[22] Temperature limits available only for *audens*, 13.2–34.2 C with equivalent percentage survival between 17.0 and 33.5 C, tolerating one day of stress at 34.9 or 12.9 C;[22] tolerance influenced by thermal history of mother, changing limiting temperatures by a maximum of 1–2 C; females at 31 C for more than 24 hours produced only inviable eggs (Oklahoma).[48]

Salinity effects available only for *audens*, did not survive at 100% seawater; lower concentrations affected temperature limits: normal range of 17–33 C at 25% seawater, 19–33 C at 50% seawater, and only 22–31.3 C at 75% seawater (Oklahoma).[22]

YOLK-SAC LARVAE

Hatching length: Ca. 3.5[1]–4.0 mm TL.[44] Size at end of stage ca. 4.5 mm TL. Yolk depletion and starvation after 3–4 days at 22 C (GED). Duration of stage in *audens* 3–4 days at 30 C, 2–3 days at 15 C, starvation without hatching below 13.2 C, suggesting that hatching time somewhat more temperature labile than yolk depletion rate.[22]

At hatching yolk sac oval; oil globule single, located in anterior end of yolk sac (GED); body elongate, slender; gut extremely short, anus about 1/4 of way from tip of snout to rear of caudal finfold.[44]

Pigmentation: Highly transparent;[16] 3–11 small melanophores over brain on head,[44] these contracting into round dots at hatching (dendritic in embryos); no other dorsal melanophores; a cluster of melanophores above gut and dorsal surface of yolk; black pigment in a line along ventral base of finfold from anus to tip of urostyle; dendritic leucophores scattered over body surface; oil globule pale yellow; eyes silver with black and gold highlights (GED).

LARVAE

Specimens described 4.7 to ca. 12 mm TL. Size at end of stage not established but before 20 mm TL,[44] probably ca. 14 mm TL (GED). At 4.7 mm TL appearance similar to yolk-sac larva.[44]

At 7.8 mm TL pectoral fins more pointed; finfold reduced in width between median fins; urostyle flexion in progress; ca. 15 caudal rays countable, ca. 8 anal ray bases countable; soft dorsal ray bases developing; pelvic and first dorsal fins still undeveloped (AJL). At 8.9 mm TL first dorsal fin still rudimentary, other median fins with full complement of rays, tending toward adult fin shape; pelvic fins formed; myomeres still visible; a vestige of fin-fold present between anus and anal fin; anus still placed far forward.[44] Aggregating by 8–10 mm; schooling at 11–12 mm TL.[64,65] First dorsal fin formed by 11–12 mm TL.[44] Between 9 and 12 mm SL (ca. 10.5–14 mm TL) anal rays on 17 out of 20 larvae were differentiated sufficiently to permit accurate counts. Caudal vertebrae in this group ranged 20–24.[6] Raised in aquaria, specimens of this size were 4 weeks old (post-fertilization).[6,63]

Pigmentation: At 4.7 mm TL dark pigment still present along gut; head melanophores unchanged; some dark chromatophores along sides over notochord. By 11–12 mm TL mid-dorsal pigmentation still slight or lacking altogether; a dark mid-lateral line present; one large melanophore figured on opercle.[44]

JUVENILES

No particular sizes described. Size at end of stage 30–40 mm SL.

Juveniles distinguished from *M. menidia* by short, triangular anal fin, lower anal ray count.[44]

Pigmentation: Distinguished from *M. menidia* by silvery peritoneum;[1] two lines of spots mid-ventrally along caudal peduncle;[14] from *Membras martinica* by the latter and also by a lateral row of melanophores on each side of the anal fin.[3]

GROWTH

Definitive growth studies lacking; modes and even means of length-frequency distributions (*M. beryllina* com-

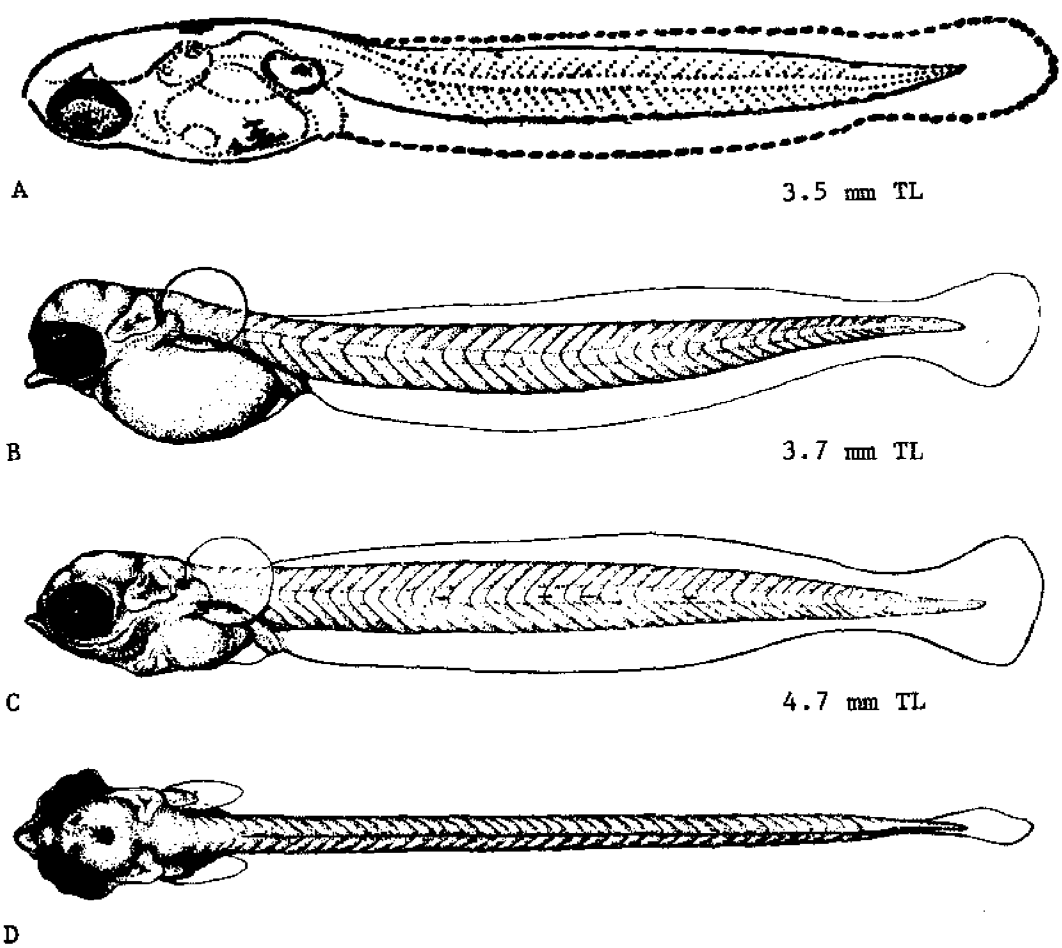

Fig. 44. *Menidia beryllina*, Tidewater silverside. A. Yolk-sac larva, 3.5 mm TL. B. Yolk-sac larva, 3.7 mm TL. C. Larva, 4.7 mm TL. D. Dorsal view of same. (*A, Hildebrand, S. F., 1922: fig. 98, reversed. B-D, Wang, J. C. S., 1974: 148.*)

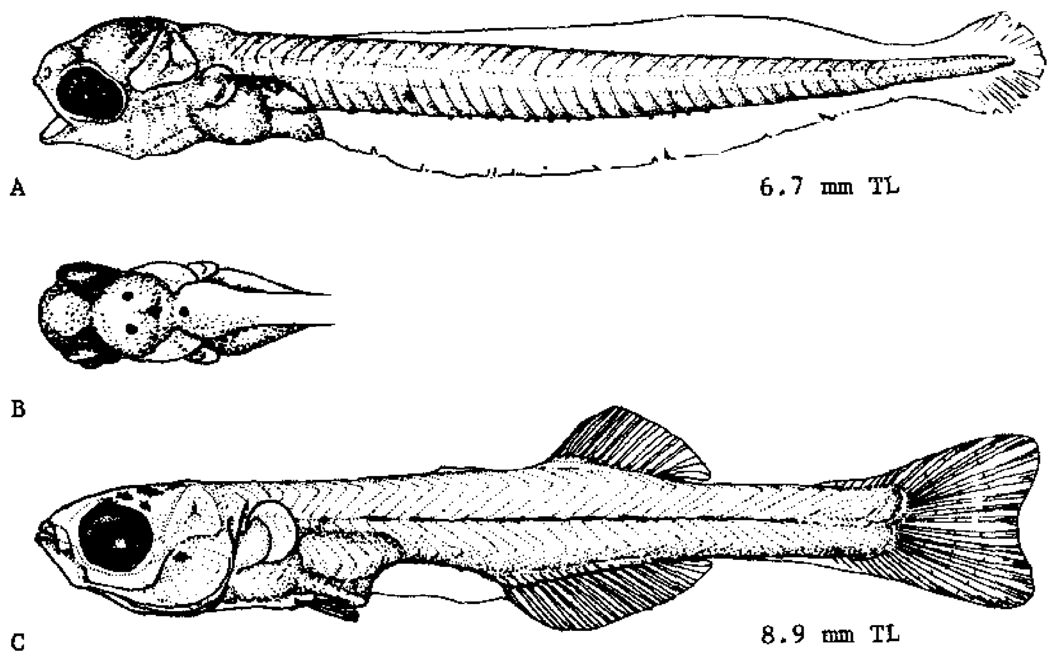

Fig. 45. *Menidia beryllina*, Tidewater silverside. A. Larva, 6.7 mm TL. B. Head of same, dorsal view. C. Larva, 8.9 mm TL. (*A, B, original drawings by Alice J. Lippson. C, Wang, J. C. S., 1974: 149.*)

plex)[10,15,17,59,68] unreliable for growth estimates, probably reflecting tendency of this species to segregate into large, spatially separated schools of like-size individuals (GED) as well as an extended spawning season.[10,16] Data from Tampa Bay suggest that late-spawned juveniles grew 5–7 mm per month from June to November, and that early-spawned juveniles grew about 8 mm SL per month from June to September (Gulf);[9] winter growth cessation indicated in Oklahoma (*audens*).[59]

AGE AND SIZE AT MATURITY

May be mature by 33 mm SL,[14] ca. 5 months post hatching (assuming growth of 6 mm SL per month, GED) fall spawning in south[9,10] may involve 0 year class; most individuals believed to spawn at about one year of age (*M. beryllina* complex). Adults usually disappear from samples in late summer, few thought to survive beyond 16 months,[59] but some probable 2 year old females reported (*audens*).[22]

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Menidia menidia (Linneaus), Atlantic silverside

ADULTS

D. III to VII ($\bar{x}$ 4.64)–I, 7–11 ($\bar{x}$ 8.56); A. I, 19–29 ($\bar{x}$ 23.6);[16] C. 17 principal rays, 9–11+9+8+9–10;[41] P. 12–16 ($\bar{x}$ 14);[16] V. I, 5;[43] branchial lateral line scales 37[2]–55 ($\bar{x}$ 44.3), ca. 11 innervated; postpectoral lateral line scales 34–47 ($\bar{x}$ 40.71), ca. 34 innervated; predorsal scales 15–31 ($\bar{x}$ 20.3); caudal peduncle scales 10–17 ($\bar{x}$ 13.4);[16] vertebrae 37[2]–47[16] (weighted means 41.4,[2] 43.3,[7] 44.2[16]), 16[41]–20 precaudal plus 22[2]–27[42] caudal; jaw teeth numerous; no teeth on vomer or palatines; gills 4.[43]

Proportions as percent of SL: Head 21–24[18] ($\bar{x}$ ca. 21.9);[3] snout 6.2[16]–8.4[3] ($\bar{x}$ 7.1,[16] 7.5[3]); eye 5.2–7.4 ($\bar{x}$ 6.5);[16] interorbital 5.8–8.5 ($\bar{x}$ 7.1);[3] greatest depth 14.4–23.2;[16] predorsal 47.4[16]–58.9[3] ($\bar{x}$ 53.3,[16] 54.9[3]); preanal 51.6[16]–59.2 ($\bar{x}$ 56.2,[7] 58.8[16]); prepectoral 23.0–26.7 ($\bar{x}$ 25.0);[3] pectoral length 16.6[16]–25.6[3] ($\bar{x}$ 19.1,[16] 21.0[3]); pelvic length 10.1–13.3 ($\bar{x}$ 11.3).[16]

Body elongate, slender and terete to robust (most robust in the south), rounded to depressed dorsally, rounded ventrally, moderately rounded laterally to somewhat slabsided (southern populations); caudal peduncle evenly rounded to distinctly angular in cross-section; dorsal profile horizontal or sloped slightly from snout to first dorsal origin, flat between dorsal origins, sloped downward along second dorsal base, mostly horizontal along caudal peduncle, ventral profile sloped downward from head to vent and upward in almost a straight line along anal base and caudal peduncle. Head triangular,[16] flattened above;[28] snout moderate in length, blunt to subconic (blunter in males); eye relatively small, its diameter usually less than snout length.[16] Mouth oblique, nearly terminal,[18] jaws equal; premaxillary rounded anteriorly[16] and strongly curved;[1] maxillary not reaching front of eye;[27] lower jaw included;[1] teeth retrorse, in two rows which conjoin on posterior third of mandible; outer teeth of mandible stout, largest teeth in outer row of upper jaw, these somewhat more anteriorly projected.[16] Gill membranes separate, free from isthmus,[43] pseudobranchiae present.[18] Scales moderate, cycloid,[17] well imbricated, variable in thickness (thinner in more northern populations),[16] margins entire,[18] smooth posteriorly, scalloped anteriorly;[3] circuli usually visible in all scale fields, radii range from well developed to barely discernible; caudal peduncle scales shield-shaped; scales anterior to first dorsal fin somewhat higher than long. Branchial and postpectoral lateral lines complete. Origin of first dorsal fin ranging from over posterior border of anus to almost directly over anal fin origin; usually closer to caudal base than to snout tip; second dorsal origin over eleventh or twelfth anal ray,[16] about the length of its own base behind the first dorsal origin, longest rays almost twice height of first dorsal fin; caudal large and moderately forked;[17] anal fin long,[16] about an eye diameter longer than the head,[18] slightly falcate,[16] its origin under the middle[17] to front[16] of the first dorsal fin base; pectoral fins broad, moderately long, their tips rounded somewhat; pelvic fins short, rounded[16] or truncated, about half as long as head, inserted about under tip of pectorals[17] midway between snout tip and caudal base[3] or nearer the former.[18] Scales present on head,[28] and extending somewhat on caudal fin base, but not on base of soft dorsal[18] or anal fins.[18,47] Air bladder abruptly truncate in shape posteriorly, its tip scarcely reaching a point over anal fin origin,[16] not passing second anal ray.[2]

Pigmentation: Above transparent green[17,43] to greenish yellow (southern populations);[43] below more or less silvery with metallic luster in life,[27] belly white;[17] a well defined bright silver band (stole) about half as wide as eye, edged above by a dark line, on sides from upper pectoral base to caudal base;[17,18,27] a dusky mid-dorsal streak; above stole the pigmentation evident as spots on ventral edge of scale sockets, melanophores progressively more diffused dorsally over exposed scale fields; below stole scale pockets lightly outlined by small spots, belly scales and those just posterior to pectoral fin base not outlined;[16] chin, top of head and snout dusky,[16,27] fleshy part of snout with a scattering of small melanophores uniform except for a concentration around nares; light spotting anteriorly around eye; operculum lacking pigmentation. Dorsal and caudal fins uniformly spotted along rays to fin tips; anal fin pigmentation highly variable from virtually unpigmented to uniform spotting along rays to tip of fin; pectoral rays usually pigmented but this sometimes restricted to upper 3–6 rays; pelvic fins clear;[16] caudal fin tinged with light yellow.[43]

Maximum size: 144 mm TL,[10] 123 mm FL,[21] or 117 mm SL (largest among 1500+ individuals from throughout the range).[16]

DISTRIBUTION AND ECOLOGY

Range: Atlantic coast of North America from north of 47° N in New Brunswick, Nova Scotia and the Magdalen Islands[17] to Volusia County, Florida.[2] A single specimen reported from Bermuda[61] verified as this species, but the collection data questioned.[16]

Area distribution: Widespread and abundant in coastal waters and lower tributaries of the entire area;[16,18,46] throughout the Chesapeake Bay;[18] entering James, Rappahannock and Pamunkey rivers, penetrating as far as

48 km upriver from the mouths,[46] but progressively rarer and replaced by *M. beryllina* in fresher waters.[18]

Habitat and movements: Adults—chiefly close to sandy and gravelly shores,[17,27,40,15] common on open beaches; [16,40] abundant in tidal creeks [24,40] and near the mouths of rivers; [30,46] adults significantly more abundant over sand fill than naturally vegetated bottoms; [47] not as closely associated with protected and vegetated habit as *M. beryllina;* [16] seldom along rocky shorelines [27] or in freshwater; [18] listed as present but rare over continental shelf.[29] Salinity records from freshwater [14,21,40] to 37.8 ppt; [21] exact details of salinity tolerance and preference still unknown; [16] about 21% of catch in short Delaware tidal creeks from freshwater. Temperature recorded at 1.0 [45] to 36.0 C; [50] summer-collected fish avoided temperatures above 30 C, the avoidance behavior breaking down above 32 C resulting in death within an hour or so at 32–36 C (acclimated at 4–30 C); [32] median tolerance limits range from 1–2 C (lower) to 32–34 C (upper).[?] Depth of capture to 49 m in beam trawl hauls; [18] 33% of the catch taken in surface trawl versus seine in a comparison test (only 3% of *M. beryllina* in trawl catch of same study); [38] large adults taken 8–15 km offshore in late fall and winter,[5,26] but also present in shallow water where they have been taken through ice.[27,58] Local

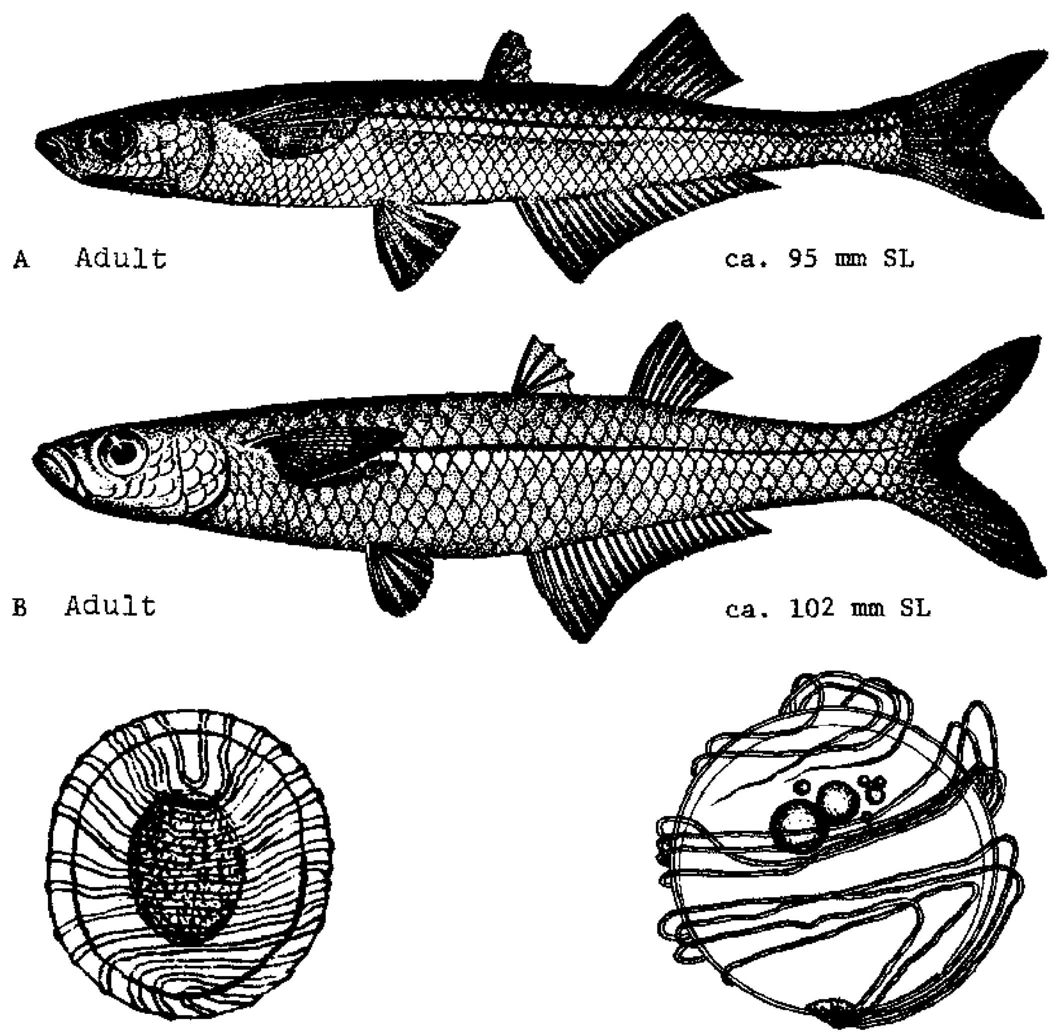

Fig. 46. ***Menidia menidia***, Atlantic silverside. A. Adult (Massachusetts), ca. 95 mm SL. B. Adult (Florida), ca. 102 mm SL. C. Young ovarian egg, filaments tightly coiled, nucleus conspicuous. D. Unfertilized egg freshly deposited in water, filaments loosely coiled. *(A, B, Kendall, W. C., 1902: 263. C, D, Ryder, J. A., 1883: figs. 1, 2.)*

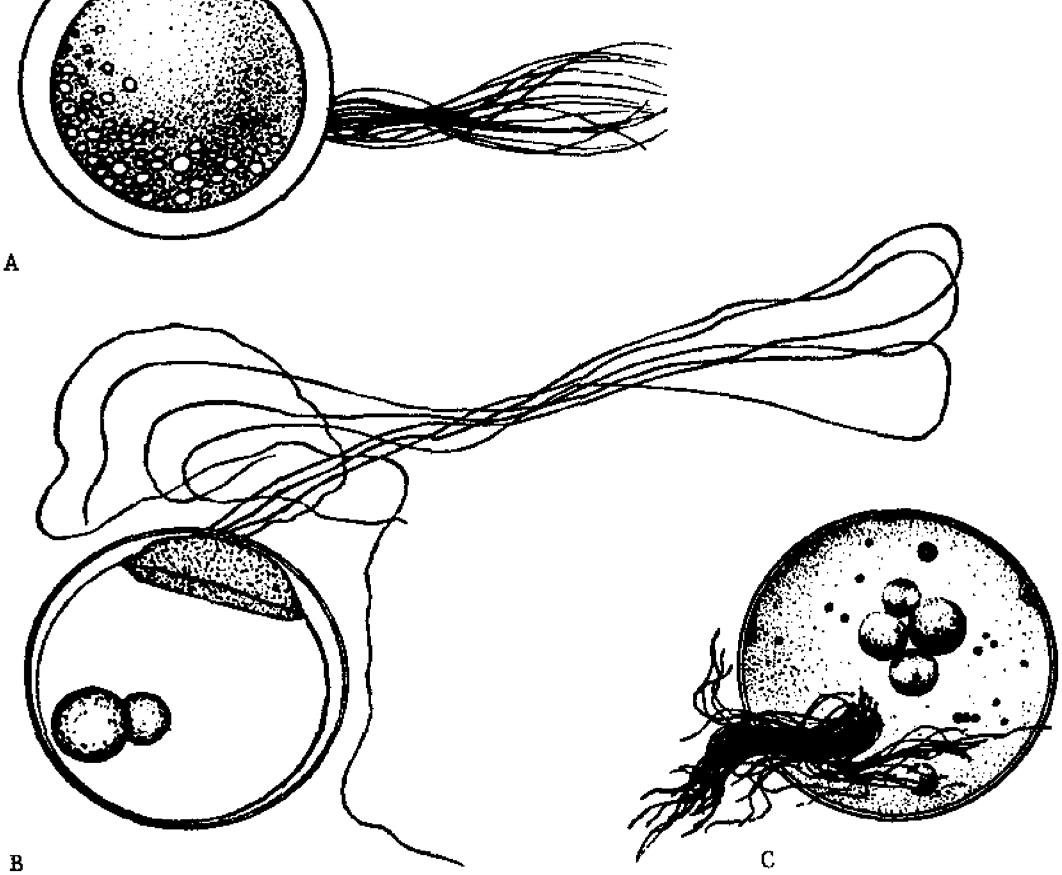

Fig. 47. *Menidia menidia*, Atlantic silverside. A. Egg (diagrammatic), only bases of filaments shown. B. Unfertilized egg after several hours in water, showing filaments entire, uncoiled, and parthenogenetic formation of germinal disc. C. Mature unfertilized egg, micropyle at upper right. (*A, Wang, J. C. S., 1974: 143. B, Ryder, J. A., 1883: fig. 3. C, Kuntz, A., and L. Radcliffe, 1917: fig. 101.*)

movements include following tidal ebb and flow in large schools [12,27,45,51,54] often entering flooded beach grass at high tide; [27] seasonal movements less well understood but entry of tidal creeks in late summer,[6,40] disappearance from other areas at the same season [6,11] and winter occurrence offshore [5,26] suggest that seasonal patterns exist (GLD).

Larvae—at 7–10 mm TL observed in closely packed but randomly oriented aggregations at the surface of shallow water near the shore, also drifting at the surface of water 1.8 m deep; [36] most conspicuous in intertidal zone by day,[35] but taken in fair abundance in plankton tows and tide traps; [35,59] 5–8 mm TL suggested to represent a planktonic phase with a certain limited dispersal capability; 5–15 mm TL larvae present at night between 60 and 100 m from shore, but individuals larger than 8 mm TL apparently less subject to removal from bays by tidal currents.[35] Details of salinity tolerance unknown, lab survival much better at 30 ppt than at 20 ppt.[33] Temperature 14.8–23.0 C larvae reared at 20 C showed maximum tolerance to thermal elevation shocks of 8–14 C.[9] Depth of capture seldom stated, a single individual reported from a midwater plankton tow at ca. 6 m,[53] many from "just below the surface." [35] Movement in oriented schools begins at 8–10 mm TL,[15,35,36,37] schooling in groups of generally 30–50 individuals in rectangular array; [36] following tides in the intertidal zone; [35,54] found in incoming but not outgoing bay tidal currents.[35]

Juveniles—habitat not differing from adults except smaller individuals present in greater profusion over naturally vegetated bottom than sand filled bottom,[47] no individuals less than 26 mm FL taken at beach station in seasons when abundant at more protected stations.[21] Salinity probably same as adults; in Chesapeake Bay

1–14 ppt with a mode near 7 ppt. Temperature 3–31 C, concentrated at 18–25 C.[25] One 26 mm FL juvenile reported ca. 18 km offshore in October.[5] Juveniles indicated to move upstream in tidal creeks before adults in summer; [40] thought to retreat to deeper water in the fall; [8] moving locally with tides.[54]

SPAWNING

Location: In the intertidal zone [1,13,34,57] or shallow water [1] of estuarine areas; [22] probably seaward with respect to areas used by *M. beryllina;* [40] spawning in schools.[1,34,57]

Season: Mass spawning witnessed in April (Maryland),[34] May (Virginia,[57] North Carolina [1]) and June (Massachusetts); [13] spent fish not reported before April (Maryland); [4] ripe fish in June (Canada),[58] late May–July (Massachusetts),[7,15,39] March–July (Chesapeake Bay region),[4,18,22,24] March–July and September (South Carolina); [23,33] larvae present in June–July (Massachusetts),[35] May–July (New York,[9] New Jersey [59]), May–August (Delaware,[19] probably Rhode Island [8]), May–November (Chesapeake Bay),[25] most adults spent by early July in Woods Hole region; [39] temperature and photoperiod suggested to initiate spawning in south, temperature alone in north.[33] Modes of length frequency distributions [8,20,46,52] more cohesive than for *M. beryllina*, suggesting a more concentrated spawning season (GED).

Time of day: Daytime [57] and afternoon [34] spawning witnessed, while tide rising and nearing crest.[34,57]

Temperature: Not recorded for field spawning; ripe at 13–30 C; [19,33] distribution pattern in the north suggests that successful reproduction requires summer temperatures above 20 C.[27]

Fecundity: 500 eggs from average size females; [1] 1413 from a large female.[10]

EGGS

Location: Demersal,[1,13,31,39] in intertidal zone attached to beach trash [34] or sedges, grasses, etc.,[13,34,57] in shallow water attached to sedges, eelgrass and sand.[1,10,17,22] Eggs more or less scattered [34] or adhering to each other in clusters.[1,13,17]

Unfertilized eggs: Chorion proportionally very thick in small ovarian eggs; nucleus prominent; attachment filaments developed early, tightly coiled on chorion surface. Ovulated eggs with a strong, thick chorion; oil globules highly refringent, of various sizes. When stripped in water germinal disc diffuse, becoming distinct within ten hours without fertilization; attachment filaments at first coiled around chorion in a spiral, soon uncoiling and becoming adhesive; [31] micropyle relatively large.[39]

Fertilized eggs: Generally spherical,[17,39] seldom perfectly spherical but with various slight irregularities; [10] semi-transparent, in clusters slightly yellowish,[39] pale yellowish [1,57] or greenish; [1] egg diameter 1.0–1.2 mm,[22] 1.1–1.3 mm,[39] 1.25 mm,[1,17] 1.5 mm; [48] chorion thick; [39] yolk granular; [1] 5–12 large oil globules of unequal size and numerous smaller ones, the larger oil globules may or may not be aggregated, the smaller ones distributed more or less uniformly over yolk surface; [1,22,39] perivitelline space broadest at the germ disc, narrowest opposite this point; chorion with a tuft of elastic filaments attached in one small area of insertion,[1,22,31,39] their length ca. 8 [31] or several [10] times the egg diameter, all filaments about the same length and diameter,[22] base of each filament slightly enlarged; [31] filaments uncoiling and becoming adhesive after ovoposition,[1,31] opaque for a short period while this occurs, the process possibly hastened by the presence of sperm,[1] filaments later tangled [39] and adhering to most materials except glass.[1]

EGG DEVELOPMENT

Cleavage meroblastic, equal; second cleavage at right angles to the first, cleavage quite regular.[1]

After fertilization blastodisc forming a cap on the yolk; [1] first cleavage about 1 hr. after fertilization; [13] morula stage reached in 6 hr. at 29 C, 48 hr. at 15.5 C; embryo outline discernible in 12 hr. at 29 C, 60 hr. at 15.5 C; embryo somewhat less opaque than the remainder of the blastoderm, extending half around the egg with ca. 12 somites in 24 hr. at 29 C, 4 days at 15.5 C, the oil globule single by this time; heartbeat beginning after 2 days at 29 C, 7 days at 15.5 C; [1] 20–24 somites visible within 40 hr. after fertilization (temperature unspecified,[39] probably ca. 20 C (GED); after circulation established large melanophores appear sparsely scattered on yolk blastoderm, xanthophores and smaller melanophores on embryo,[1,39] by this time embryo has fully encircled the egg, tail free and capable of considerable movement and segmentation complete; [1] as development continues melanophores becoming aggregated in a few areas on dorsal aspect of head and in a series along base of the dorsal finfold; yolk blastoderm melanophores gradually becoming arranged along the vitelline blood vessels; small xanthophores remaining sparsely scattered on embryo for some time but gradually becoming less conspicuous.[39]

Incubation time: From 4 days at 30 C to 27 days at 15 C.[9] Incubation period may also be calculated from the following formula empirically derived (GED) from data presented by Austin, *et al.* (1975):

$$\log \text{time in days} = 2.26717 - (0.062308 \times \text{temperature in degrees C})$$

Began hatching seventh day at 22 C,[38] 8–15 days at 22–27 C,[44] 8–16 days at unspecified temperatures; [1,15,[illegible],27,39,46]

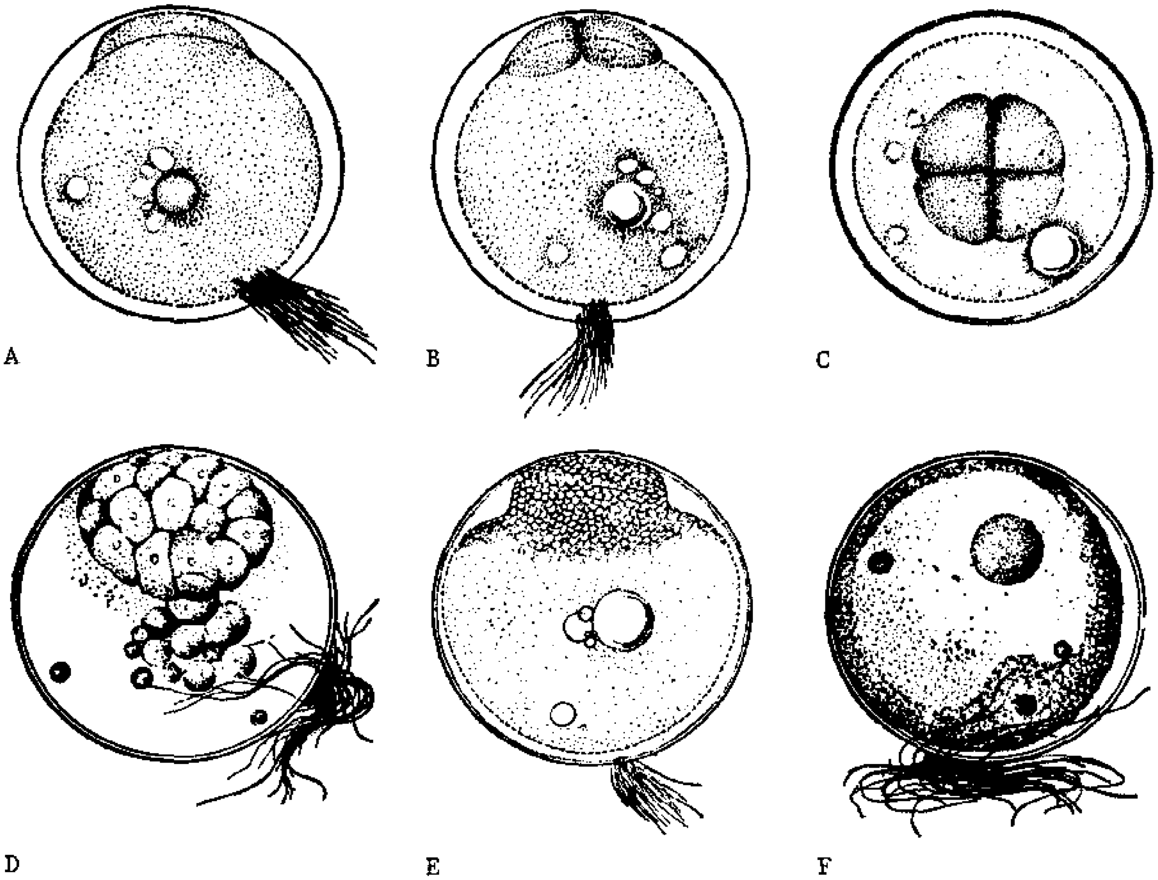

Fig. 48. *Menidia menidia,* Atlantic silverside. A. Fertilized egg shortly after fertilization. B. Egg, 2-cell stage. C. Egg, 4-cell stage, surface view. D. Egg, 16-cell stage. E. Egg, morula stage. F. Egg, germ ring stage (early gastrula). (*A-C, E, Hildebrand,* S. *F., 1922: figs. 85–87, 89. D, F, Kuntz, A., and L. Radcliffe, 1917: figs. 103, 105.*)

mortality high even at 15 C (Long Island).[9] Reduced salinity delayed emergence by 10 hr. at 20 ppt, 42 hr. at 10 ppt, also reduced percentage hatching, optimum salinity 30 ppt.[33]

YOLK-SAC LARVAE

Hatching length: Ca. 5 mm TL,[39,49] 3.8–5.0 mm TL.[22] End of stage controversial,[9] amount of yolk at hatching at least partly dependent on developmental temperature, well defined yolk sac absent at hatching when hatched at 25 C or lower [4,9,27,89] present at 30 C,[9,33] absorbed by second,[33] third [1] or fifth [49] day post-hatching, little growth in length during stage.

At hatching body shape very slender, tail extremely long;[1] anus just posterior to yolk-sac area, body tapering gradually from anus to posterior end.[39]

Pigmentation: At hatching highly transparent;[1] eyes well pigmented;[33] large dendritic melanophores and yellow chromatophores aggregated on the dorsal aspect of the head [1,22,39] and in the dorsal region of the body cavity, melanophores also present on the ventral aspect of the yolk sac, in a series along the base of the ventral finfold, and in a few small groups at the base of the dorsal finfold toward the posterior end of the body.[39]

LARVAE

Specimens described 5.5 ca. 15 mm TL; size at end of stage not established; before 20 mm TL.[22]

Caudal rays becoming apparent at 5.5 mm TL; finfold somewhat constricted between median fins.[39] At 7.0 mm TL [22] and 8.0 mm TL [39] little changed from 5.5 mm TL; urostyle flexion just beginning; anus still about 1/4 of way from snout tip to urostyle tip. At 7.5 mm SL pectoral rays shown as still undifferentiated.[3] In size range 9.0–15.0 mm SL ($\bar{x}$ 10.6 mm SL) full complement of

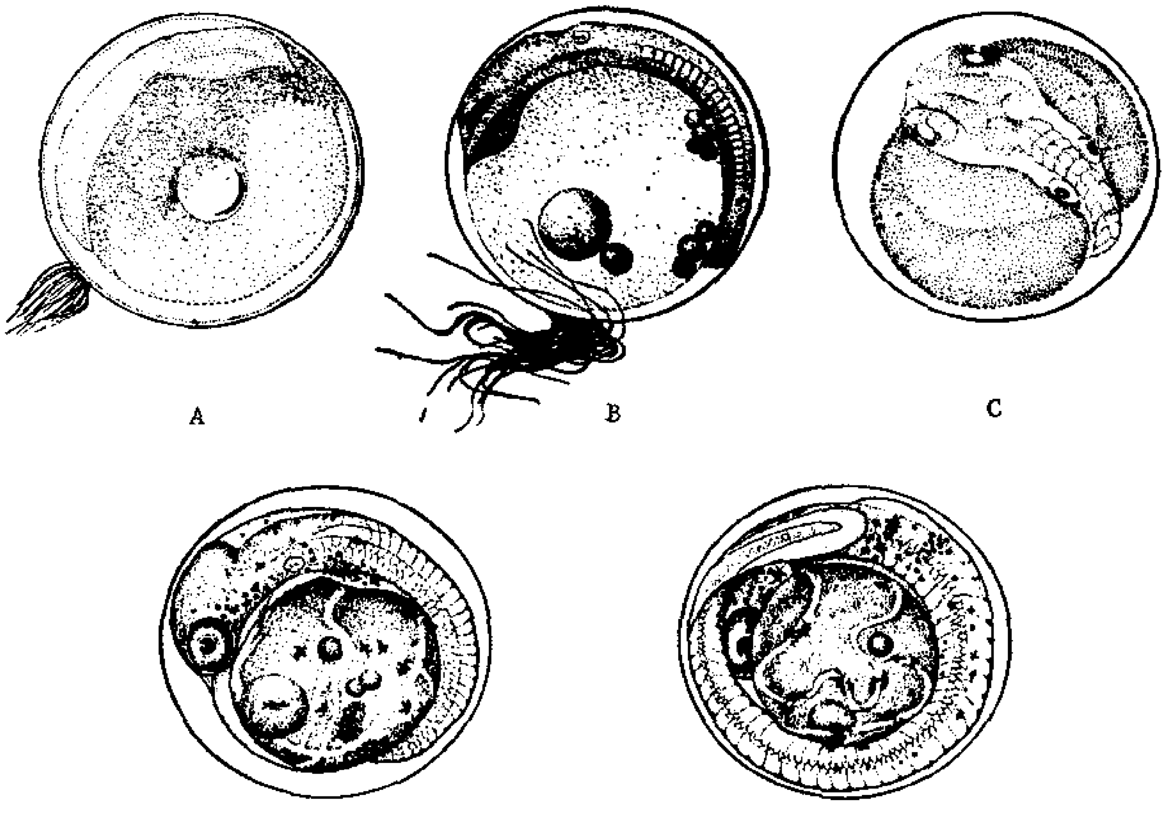

Fig. 49. Menidia menidia, Atlantic silverside. A. Egg, neural crest stage (late gastrula). B. Embryo with 22–24 somites, optic vesicles formed. C. Embryo 2 days after fertilization at 27.8 C. D. Embryo after vitelline circulation and pigmentation established. E. Advanced embryo less than a day before hatching. (*A, C, Hildebrand, S. F., 1922: figs. 90, 91. B, D, E, Kuntz, A., and L. Radcliffe, 1917: figs. 107, 108.*)

22–55 anal rays countable in only 14 out of 41 specimens; caudal vertebral counts ranged 25–26; age (aquarium reared) 4 weeks postfertilization.[7] At 11–12 mm TL and 13 mm TL first dorsal fin not developed or only bud-like; [22,39] pelvic fins not developed; vestiges of ventral finfold still present anterior and posterior to anal fin; caudal fin rounded; pectoral ray count incomplete; anus ca. 1/3 of distance from snout tip to urostyle tip, shifting toward its final midway position; [39] scales appear at some point in the interval 16.1–23.8 mm SL.[3]

Pigmentation: At ca. 5.5 mm TL yellow pigment materially reduced; melanophores more abundant on the dorsal aspect of the head and anterior trunk region; the body further marked by a series of melanophores at the base of the ventral finfold and another at the ventral level of the notochord. At 8.0 mm TL pigment distribution essentially the same.[39] In the range 9.2–12 mm TL dorsal surface melanophores arranged in 2 irregular parallel rows; melanophores also present in single lateral rows along the anal fin in addition to forming spots at the bases of the anal rays.[3,22] At 12–15 mm TL the pigment distribution observed at earlier stages still apparent; melanophores more abundant on the dorsal aspect of the body; the silvery lateral band not yet well differentiated.[39]

JUVENILES

Size range from less than 20 mm TL [22] to 50–88 mm SL.[17] A single specimen figured as 13 mm TL [1] (possibly atypically small, GED).

Caudal margin straight, head melanophores large in the putative 13 mm TL juvenile; [1] shown scaled, although scales elsewhere stated to be undeveloped at 16.1 mm SL; [3] lateral line pores appearing at 30–35 mm SL, their maturation uniform, with innervation stage similar at any given size, unlike non-uniform maturation in other *Menidia* species.[16]

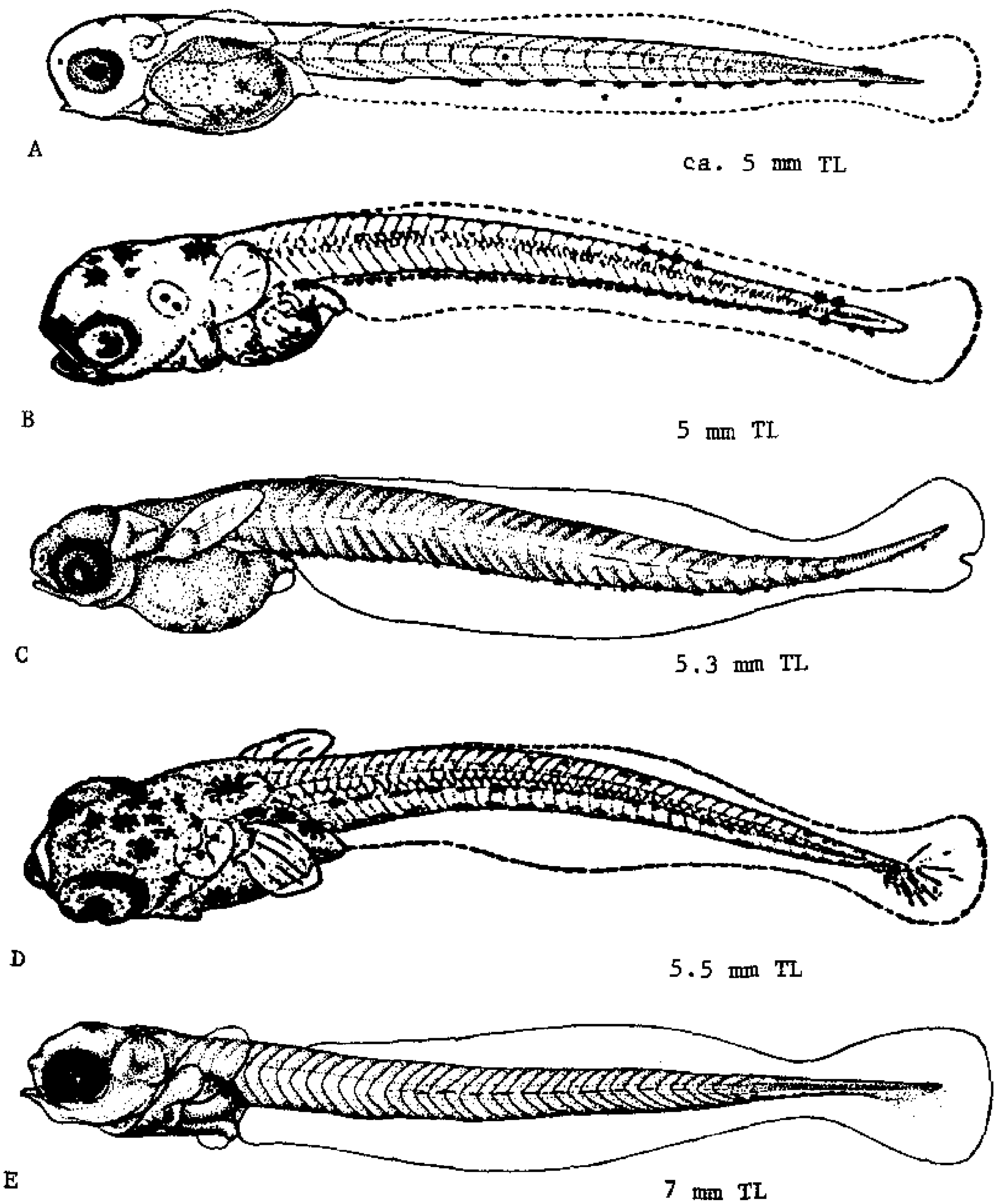

Fig. 50. ***Menidia menidia***, Atlantic silverside. A. Yolk-sac larva, newly hatched, ca. 5 mm TL. B. Yolk-sac larva, 5 mm TL. C. Yolk-sac larva, 5.3 mm TL. D. Larva, 5.5 mm TL. E. Larva, 7 mm TL. (*A, Hildebrand, S. F., 1922: fig. 93. B, D, Kuntz, A., and L. Radcliffe, 1917: figs. 109, 110. C, original drawing by Alice J. Lippson. E, Wang, J. C. S., 1974: 150, rephotographed with permission, from an original drawing by R. Lynn Moran.*)

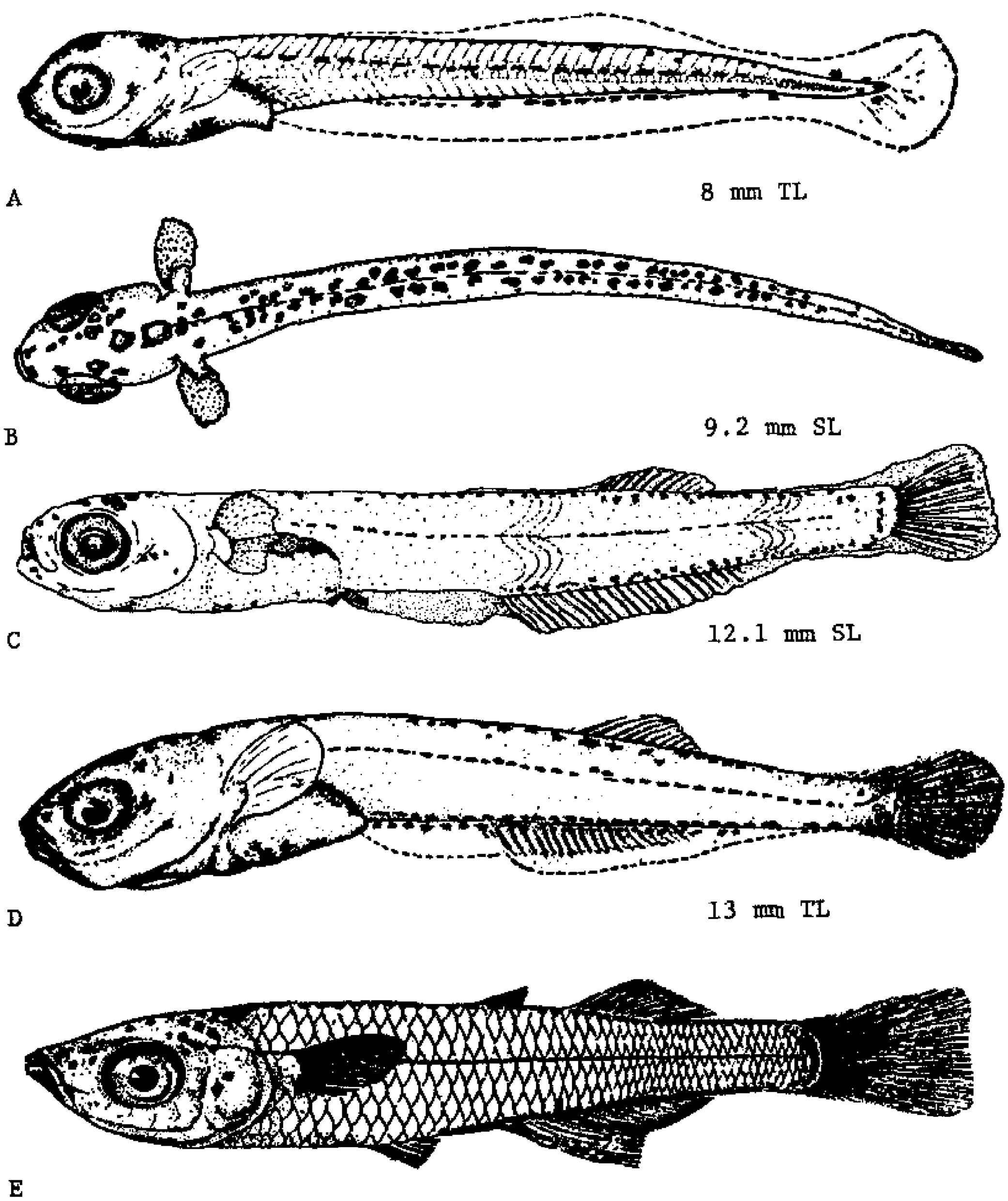

Fig. 51. *Menidia menidia*, Atlantic silverside. A. Larva, 8 mm TL. B. Larva, 9.2 mm SL, dorsal view. C. Larva, 12.1 mm SL, myomeres partially drawn. D. Larva, 13 mm TL. E. Juvenile, length problematical (see family introduction). (*A, D, Kuntz, A., and L. Radcliffe, 1917: figs. 111, 112. B, C, Kolba, C. A., 1972: figs. 5B, 5A. E, Hildebrand, S. F., 1922: fig. 94.*)

Pigmentation: In juveniles, specimens not quite like that of adults, but melanophores of dorsal surface in a more random fashion than those of *Membras*.[3]

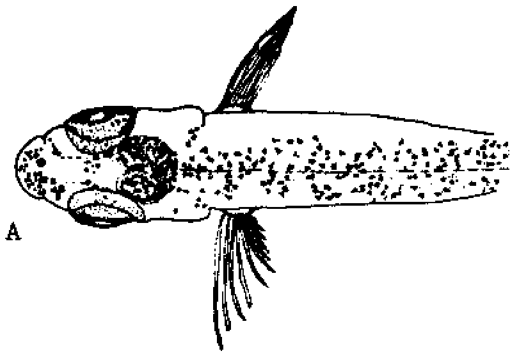

Fig. 52. *Menidia menidia*, Atlantic silverside. A. Juvenile, 23.8 mm SL, dorsal view of head. (*A, Kolba, C. A., 1972: fig. 5C.*)

GROWTH

Definitive growth studies in the field lacking; a suggestion that growth is more rapid during the early juvenile phase, ca. 14 mm per month at seaward stations, 7 mm per month at more landward stations in Rhode Island; estimates complicated because of tendency to school in groups of similar size individuals;[8] in culture reaching 8–10 mm TL in 2–3 weeks,[15,48] 27–30 mm in 48 days.[49]

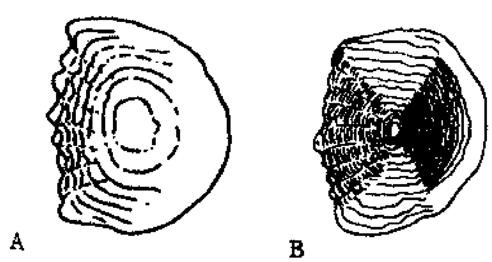

Fig. 53. *Menidia menidia*, Atlantic silverside. A. Scale from lateral stripe of juvenile 23.8 mm SL. B. Scale from lateral stripe of adult 85.6 mm SL. (*A, B, Kolba, C. A., 1972: figs. 1A, 1B.*)

AGE AND SIZE AT MATURITY

Most adults are 1 year old and 50–88 mm (TL?) in length.[17]

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Polydactylus octonemus
Polydactylus virginicus

threadfins
Polynemidae

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FAMILY POLYNEMIDAE

This largely tropical family is represented in the northwestern Atlantic by three species in the genus *Polydactylus*. Little is known about them except for adult food habits and adult and juvenile habitat preference. The two species in this area are estuarine and surf zone residents, as is typical of the family. The adults and juveniles primarily feed on shrimp and other macrocrustacea. They can be most easily separated by the number of lower free pectoral rays, seven free rays in *P. virginicus* and eight in *P. octonemus*.

Polydactylus octonemus (Girard), Atlantic threadfin

ADULTS

D. VIII-I, 11 [11]-13; [6] A. III, 13 [1,6]-15; [6] pectoral fin with 8 free lower rays; [1,6] C. 12-13+9+8+12-13; vertebrae 10+14=24; [11] scales about 58; gill rakers 21-22 on lower limb; teeth small, in villiform bands on jaws, vomer and palatine.[1]

Body proportions expressed as percent of head length: Caudal peduncle depth 45.4; snout 18.0-18.9; eye 21.0; maxillary 40.8-42.6.[1]

Body oblong, compressed with a strongly compressed caudal peduncle; [1] anterior profile almost straight; [6] head with a projecting, conical snout and eyes anteriorly placed; mouth moderate, inferior, nearly horizontal. Scales moderate, ctenoid, moderately deciduous, extending onto snout and fins. Lateral line complete, forked at caudal base, extending onto fin. First dorsal fin origin a little behind opercle, second dorsal fin origin a little in advance of the anal fin; caudal fin deeply forked; pelvic fins very small.[1]

Pigmentation: Back light olivaceous with punctulations, belly whitish; pectoral fins black.[4,6]

Maximum length: To about 305 mm.[5]

DISTRIBUTION AND ECOLOGY

Range: South Atlantic and Gulf coasts, rarely to Massachusetts.[5]

Area distribution: New Jersey,[7] Virginia portion of Chesapeake Bay.[1]

Habitat and movements: Adults—sandy shores,[4,5] surf zones,[2] open waters [8] and estuaries.[10] In Texas waters, movement is inshore in late spring summer; [2] Louisiana waters, enter estuaries in spring,[10] leave inshore waters when the water temperature drops; [9,10] euryhaline [8] living in a range from 1.6 [10]-36.7 ppt salinity, but being least common in intermediate salinities; inshore when the surface temperatures are 18.4-32.0 C; [9] found from 14.8 C to 34.9 C, but most common about 20 C.[10]

Larvae—no information.

Juveniles—shallow water with sandy bottom.[4]

SPAWNING

Probably offshore in late winter or early spring.[9]

EGGS

Probably pelagic.[8]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

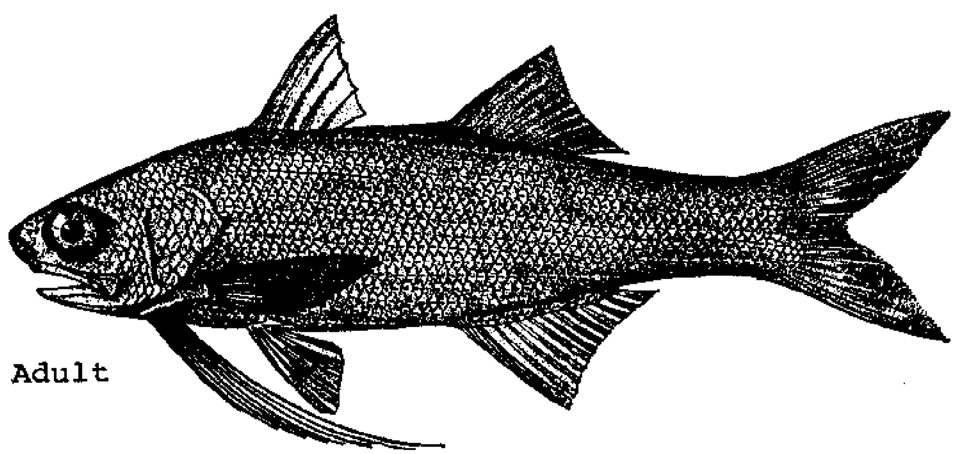

Fig. 54. *Polydactylus octonemus*, Atlantic threadfin. A. Adult, length unstated. (*A, Hildebrand, S. F., and W. C. Schroeder, 1928: fig. 113.*)

JUVENILES

Like adult except that pectoral fins are pale.[4]

GROWTH

Based on length-frequency data: June, 23–43 mm, mode at 33 mm; July, 33–53 mm, mode at 43–48 mm; August, 53–83 mm, mode at 78 mm; thereafter modes are difficult to distinguish and the smallest size group merges with the next larger group.[9]

AGE AND SIZE AT MATURITY

No information.

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Polydactylus virginicus (Linnaeus), Barbu

ADULTS

D. (VII [1]) to VIII–I,[1,2,3,7,9] 10–13 [3] (9–12); [7] A. III,[1,2,3,7,9] 12–14; [2,3] P. 15 upper (attached rays) [2,3]+7 lower (free) rays; [1,2] C. 9+8; vertebrae 10+14=24; scales 53 [2,3] or 54 [1]–62 [1,3] or 65; [2] gill rakers 11–13+16–17 [3] or 12+1+14–16; teeth in villiform bands on mandible, palatines, vomer and pterygoids; branchiostegals 7.[1]

Proportions as percent of SL or HL: Head 30.0–32.0 SL, depth of body 28.1–30.3 SL; [1] anal fin base 17.2–19.2 SL; [2] snout 20 HL; maxillary 44.4 HL.[7]

Body deep, compressed, anterior profile nearly straight; [7] head with a conical snout projecting in advance of the mouth and with the eyes located very far forward; mouth large, almost horizontal and inferior; [1] gape extending to well behind the eye; scales large, loose and slightly ctenoid.[9] Lateral line straight, bifurcating at the base of the caudal and extending onto the caudal fin. Two well separated dorsal fins,[1,9] pelvic fins abdominal,[1] caudal fin forked,[1,9] and all fins more or less scaly.[9]

Pigmentation: Dorsum grayish blue,[1] whitish olive [6,9] or yellowish white, scales on dorsum with dark punctulations on their margins; [7] sides and venter silvery,[1] dirty white,[6,9] or yellowish white; [7] sides of head yellowish silver; [1] pectoral fin with an irregular black blotch above, lower, free rays white,[6,9] or upper part dark, almost black; [1] pelvic fins dark; [1,6,9] anal fin pale with dark punctulations [6,9] or dark gray; [1] dorsal fin pale with dark punctulations,[6,9] or yellowish.[1]

Maximum length: Probably not exceeding 305 mm SL.[2,6]

DISTRIBUTION AND ECOLOGY

Range: New Jersey [1] to Brazil,[2,3] or Uruguay [1] including the West Indies.[2,5]

Area distribution: New Jersey [11] and lower Chesapeake Bay.[3,10]

Habitat and movements: Adults—sandy areas near beaches, often in only a few centimeters of water, also mangrove lagoons and brackish waters.[1] Enter river mouths.[8]

Larvae—no information.

Juveniles—over soft bottoms.[4] Very common over silty sand near river mouths in Puerto Rico (FDM).

SPAWNING

Small juveniles present throughout the year in Puerto Rico suggesting a prolonged spawning season there (FDM).

EGGS

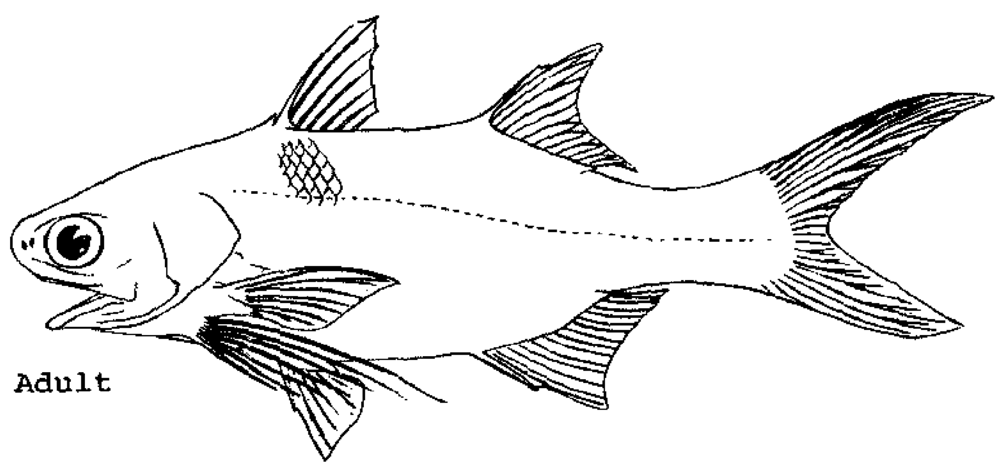
Probably pelagic.[5]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.



Adult

Fig. 55. Polydactylus virginicus, Barbu. A. Adult, 240 mm TL. (A, Cervigon M., F., 1966: fig. 109. Figure reversed. © Fundación La Salle de Ciencias Naturales, Caracas. Used with permission of the publisher.)

LARVAE

No information.

JUVENILES

At 30 mm SL, bright silvery white with no markings or dark pigmentation noticeable in most specimens in life; fins turn dusky after death (FDM). Juveniles of unstated size listed as silvery white.[7]

GROWTH

Juveniles in December 32–50 mm, in July 65–105 mm SL.[4]

AGE AND SIZE AT MATURITY

No information.

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Bothus ocellatus
Bothus robinsi
Citharichthys arctifrons
Citharichthys spilopterus
Etropus crossotus
Etropus microstomus
Hippoglossina oblonga
Monolene sessilicauda
Paralichthys dentatus
Scophthalmus aquosus
Syacium papillosum

lefteye flounders
Bothidae

FAMILY BOTHIDAE

The flatfishes have been variously divided into families. Within the region there are four or more families, depending on the classification system used. These four are Pleuronectidae, Bothidae, Soleidae and Cynoglossidae. The family Bothidae may or may not be split into the Bothidae and the Scophthalmidae (Berg, 1958; Gosline, 1971; Greenwood, *et al.*, 1966; Norman, 1934). More recently a body of information suggests that the Bothidae of the more restricted sense should be further divided into two or three more restricted families. With the exception of Amaoka (1969), the main body of this information has not been published. Due to conflicts among these proposed systems as to how many families there are and which species would go into which family, it is deemed most useful for this volume to simply refer to the Bothidae, *sensu latu*, and consider it as containing the Scophthalmidae. Accepting this classification, the bothids can be distinguished from the pleuronectids and the soles by usually having both eyes on the left side of the head. They can be distinguished from the cynoglossids and the soles by having the preopercular margin free. The only source of confusion would be reversed specimens of either bothids or pleuronectids. However, even these can be distinguished by an examination of the optic nerves because the right nerve is always dorsal in bothids, even in reversed specimens (Böhlke and Chaplin, 1968). Another point distinguishing these two families is that bothid eggs have one or, at most, two or three oil globules while most pleuronectid eggs have none.

In bothids there are two methods of eye migration. The right eye of fishes of the genus *Bothus* moves through a deep groove in the head with the tissue in the path apparently being absorbed and regenerated, while in all the others known, the eye migrates more externally over the head, though in some a preformed groove or notch is apparent.

Most bothid larvae in the area, along with some of the pleuronectid larvae, have a postanal vertical pigment band at some stage. This band is frequently confined to the body surface but in some species it extends well onto the finfolds.

Another common larval characteristic of bothids is the presence through a large part of the larval stage of elongate anterior dorsal rays or tentacles, the number and degree of elongation varying widely. No known pleuronectid larvae have these, but some soles and cynoglossids do.

Bothus ocellatus (Agassiz), Eyed flounder

ADULTS

D. 76–91;[1,7] A. 58[1,7]–69;[14] C. 17, rarely 16,[17] 9+8;[20] P. ocular side 8–10,[1,20] usually 10, blind side 7–10, usually 10;[17] left V. 6, right V. 5 (JWT); scales 70[1,11]–78;[1,14] vertebrae 10+25–27,[1,7,17] modally 10+26;[17] gill rakers short, 0–6[1]+7–10;[1,17] teeth fine, conical, 2 series in upper jaw, outer row with larger teeth than inner row,[11,17] 2 series in lower jaw, outer teeth large and few in number.[17]

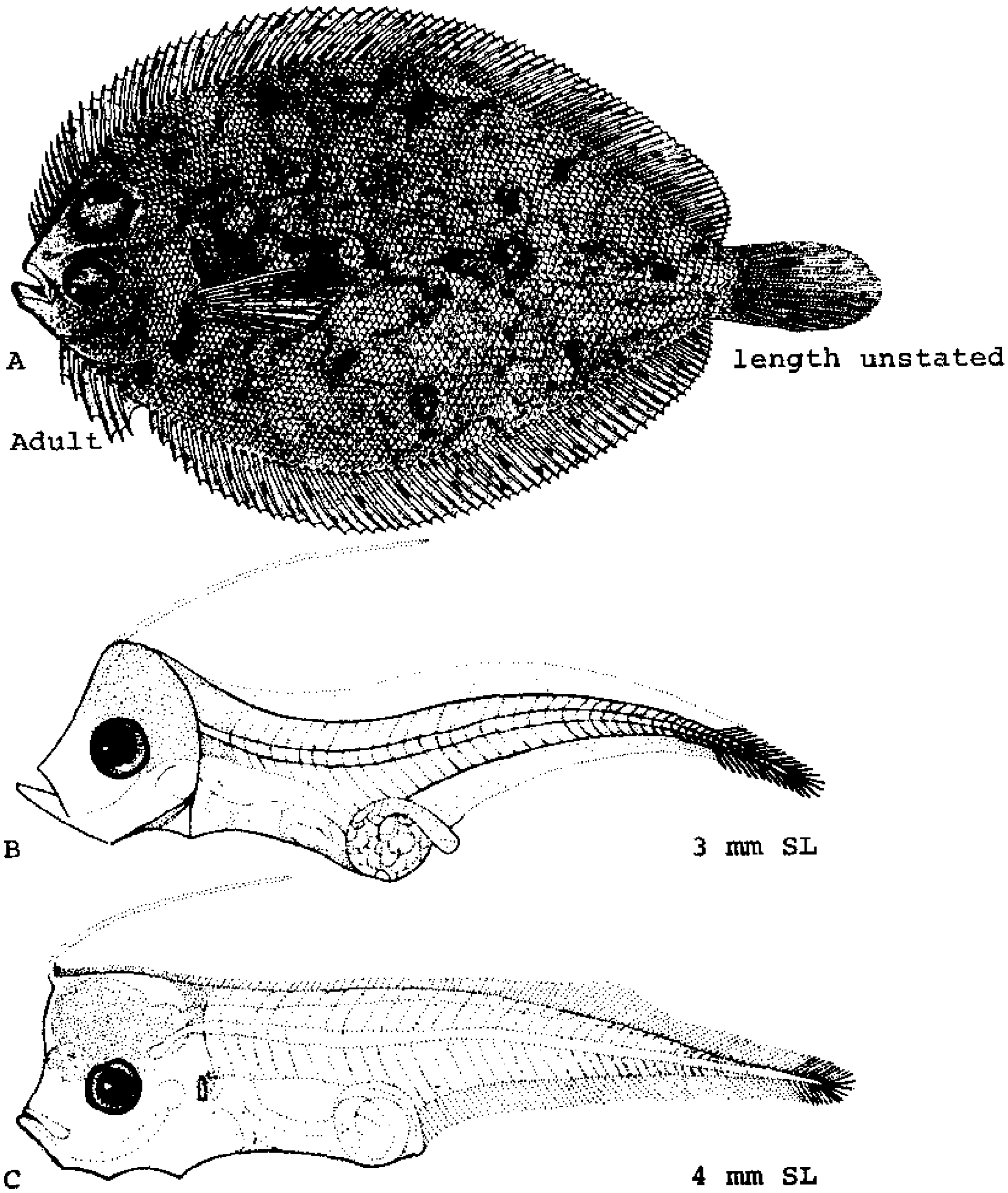


Fig. 56. *Bothus ocellatus*, Eyed flounder. A. Adult, length unstated. B. Larva, 3 mm TL. Note that myomere numbers as indicated do not equal a possible vertebral number for this species. C. Larva, 4 mm TL. Myomere numbers as indicated do not equal a possible vertebral number for this species. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 939. B-C, Jutare, T. V., 1962: fig. 11A, used with permission of author.*)

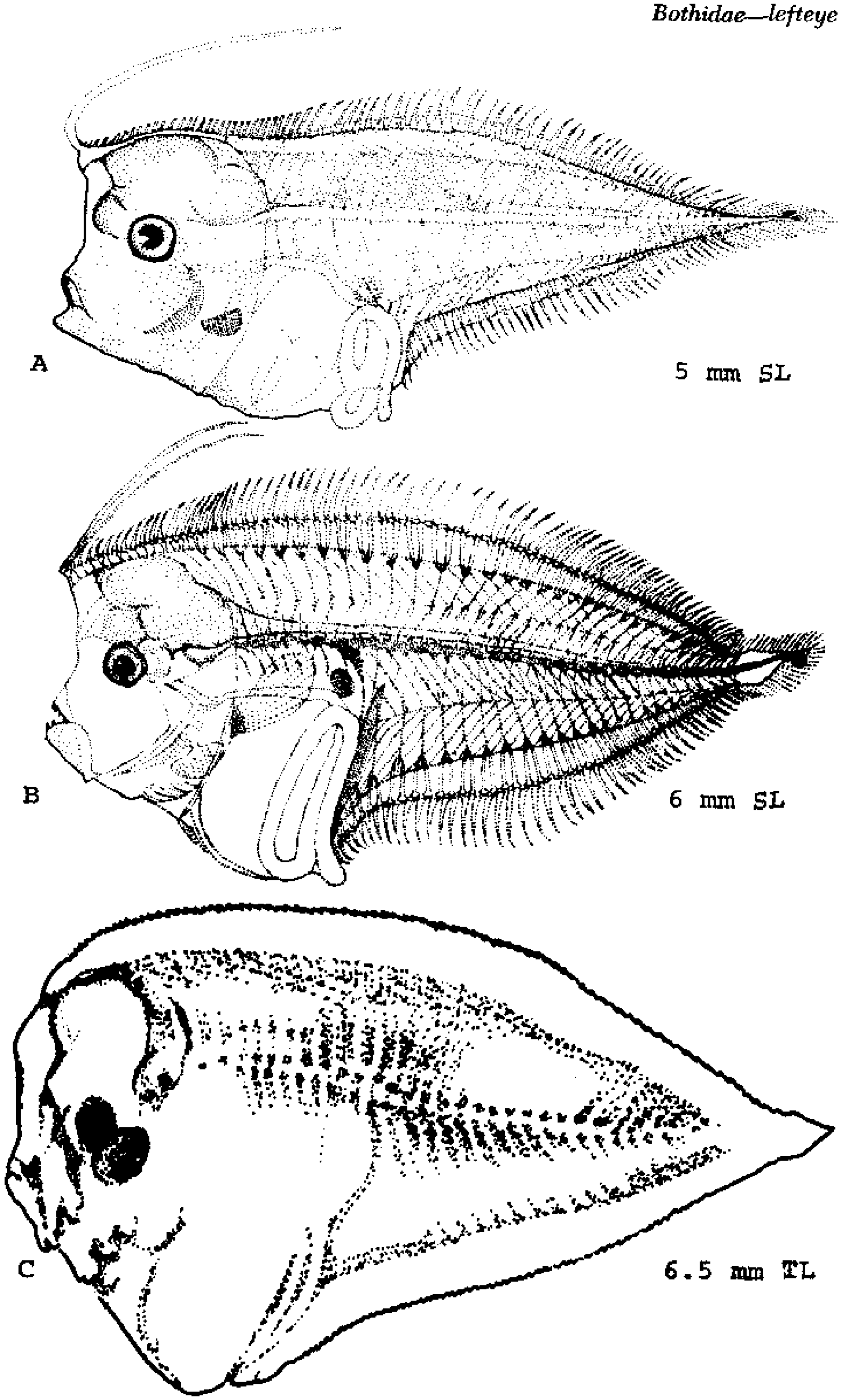


Fig. 57. ***Bothus ocellatus***, Eyed flounder. A. Larva, 5 mm. Myomere number as drawn does not match a possible vertebral number for this species. B. Larva, 6 mm. Note branched cephalic tentacle which is not indicated at any other size. C. Larva, 6.5 mm TL. (*A, B, Jutare, T. V., 1962: fig. 11A, used with permission of author. C, Colton, J. B., Jr., 1961: fig. 1, delineated by Donna Jean Davis.*)

Proportions as percent SL or HL: Body depth 58.8 [14]–70.0 [1] SL; head length 24.5 [2]–30 [1] SL; eye 22.2 [14]–30 HL; upper jaw length 24–27 HL.[1]

Body ovate, deep anteriorly; [11] head with a slightly concave profile in front of the widely separated eyes in males but not females; [17] mouth very small and oblique,[11] maxillary to or slightly beyond a vertical through anterior edge of eye.[1,11,17] Scales moderate,[11] a few ctenoid on the ocular side, all cycloid on the blind side.[11,17] Lateral line with a distinct arch anteriorly.[11,13] Upper pectoral fin rays of males elongated; [3,14,17] dorsal fin origin opposite anterior nostril, left pelvic fin beginning under middle of lower eye,[11] with a long bar on the ventral margin extending to tip of urohyal, right pelvic fin above the margin and short-based.[1]

Pigmentation: Color pattern changeable: dark phase, dark gray with darker nuclei; four submarginal nuclei following the dorsal contour, three similar following the ventral outline and three equally placed along the straight portion of the lateral line. Intermediate phase, drab with scattered circular and elliptical spots of cream; light areas and dark areas darkest at their periphery. Males with preocular region streaked with blue lines with clusters of yellow between. Light phase not described.[3] Two dark spots at base of caudal rays, one below, one above the midline, sometimes absent or indistinct.[1]

Maximum length: About 200 mm.[13,15]

DISTRIBUTION AND ECOLOGY

Range: Atlantic coast of U.S. from Long Island to Florida, West Indies, Caribbean Sea, Atlantic coast of South America to Rio de Janeiro,[1,3,13,14,17] Bermuda,[13,14] Bahamas.[21] Larvae are found to just west of the Azores.[15,22] Records from the west coast of southern India [6] are probably in error (FDM).

Area distribution: Off New Jersey,[16] Delaware,[4] and Virginia,[22] throughout the Chesapeake Bight.[7]

Habitat and movements: Adults—clear, shallow water over sand,[17] along sandy shores,[15,19] in channels [3] or in muddy or sandy bays, more frequently on sand; [2] 20–32 C; 24.1–37.6 ppt [23] at depths of from 3.6 m [17] to 108 m.[3] Most frequently taken in clear, protected waters (FDM).

Larvae—planktonic, in the top 250 m with most in the top 100 m,[17] highest concentrations off Cape Lookout to east of Chesapeake Bay near the edge of the continental shelf.[22]

Juveniles—shallow water along sandy shores,[3] sandy tidepools (FDM).

SPAWNING

Location: Probably inshore with eggs carried offshore by currents.[17]

Season: In the south Atlantic Bight larvae are present in

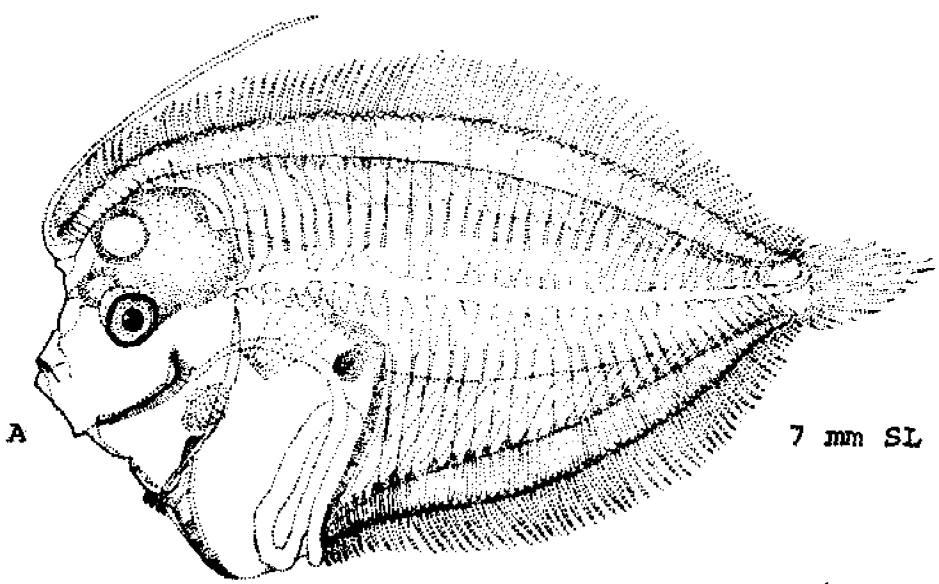


Fig. 58. *Bothus ocellatus*, Eyed flounder. A, Larva, 7 mm SL, pelvic fin formed but small. (*A, Jutare, T. V., 1962: fig. 11B, used with permission of author.*)

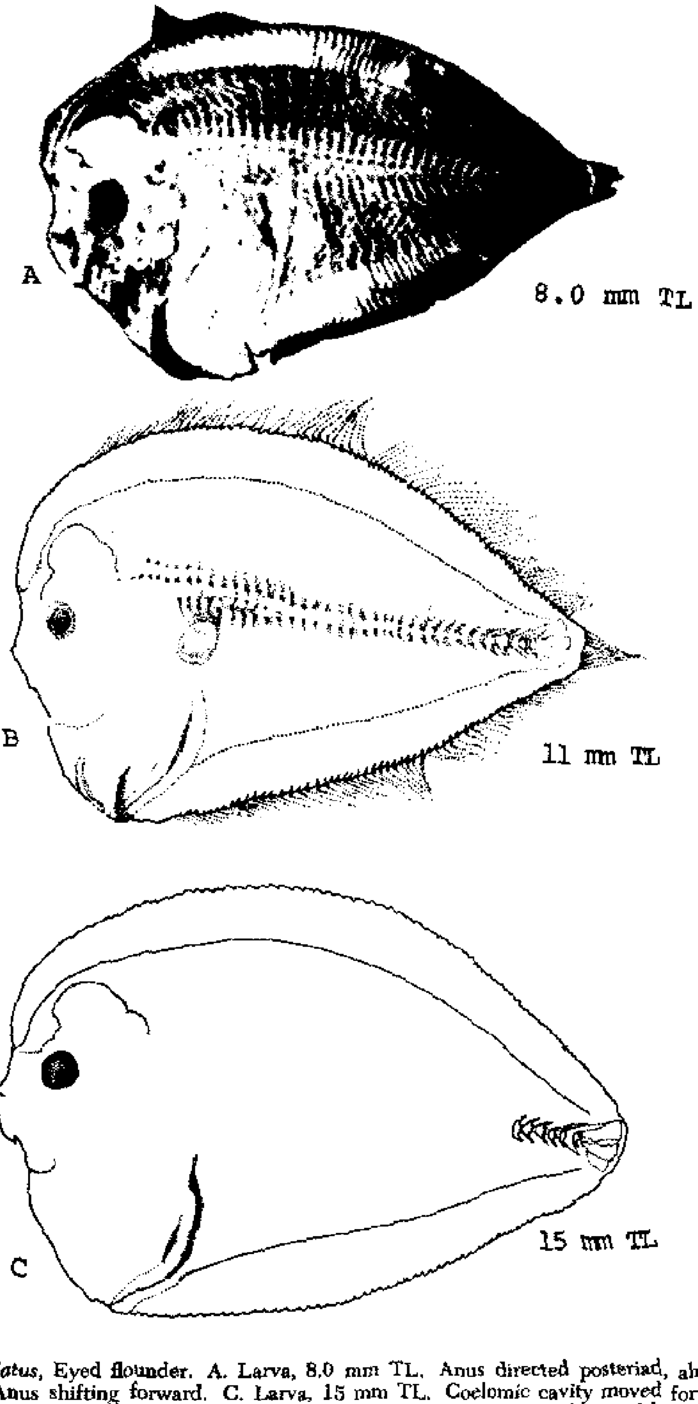


Fig. 59. *Bothus ocellatus*, Eyed flounder. A. Larva, 8.0 mm TL. Anus directed posteriad, almost papillose. B. Larva, 11 mm TL. Anus shifting forward. C. Larva, 15 mm TL. Coelomic cavity moved forward to a position more under the head. (*A-C, Colton, J. B., Jr., 1961; figs. 1B–1D, 1C and 1D delineated by Joan Ellis.*)

all seasons indicating year-round spawning [6] but peaks are noted in July and December; [17] within Chesapeake Bight peak in May and November, may be a mixture of *B. ocellatus* and *B. robinsi*.[22]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

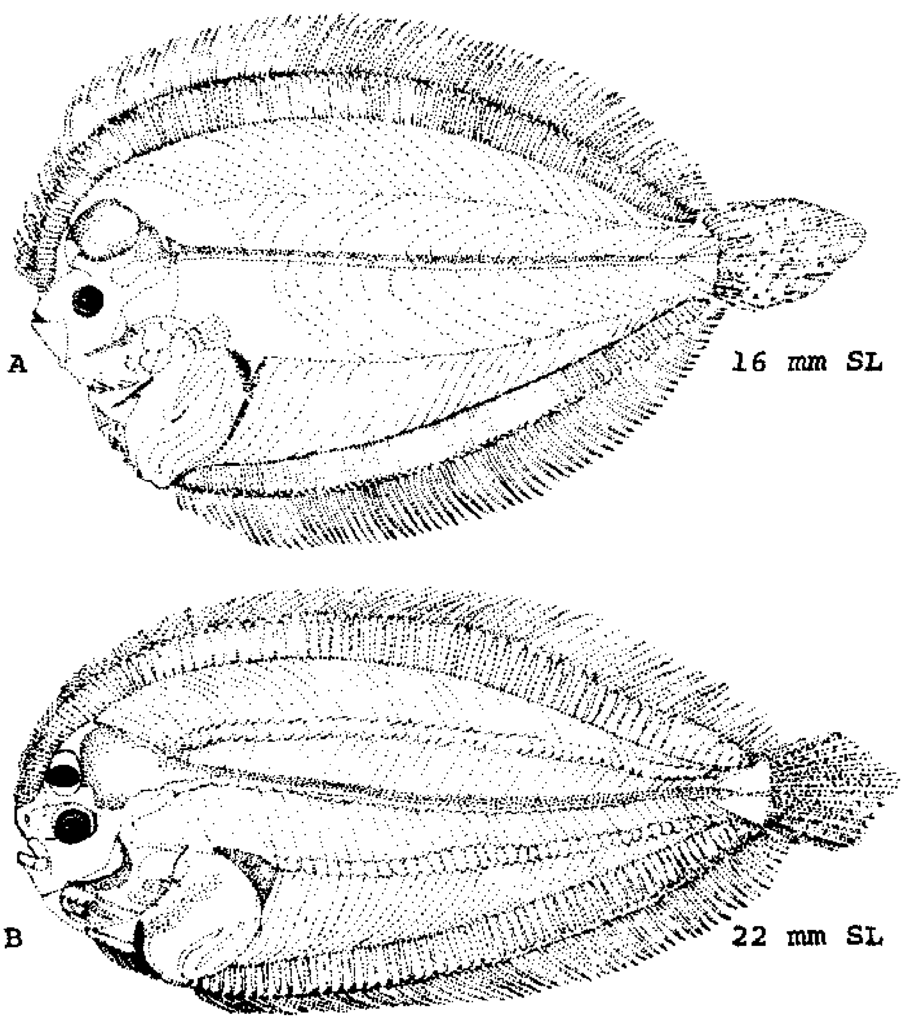
No information.

LARVAE

To 21 mm, [17] but northern larvae may not metamorphose until after 42 mm,[6,17] some (possibly *B. robinsi* rather than this species) metamorphose at 9–12 mm.[17]

Body pear-shaped in outline with the caudal peduncle *being the small end of the pear;* [12] anterior profile blunt [12,17] with well developed, slightly projecting jaws; [17] eye migrates through head at metamorphosis rather than around.[12,17] First dorsal fin ray elongated and tentacle-like; *appears at about 3 mm and disappears at about* 13 mm.[17] Notochord of the genus does not flex upward as much as that of other genera.[12] Gut coiled and not reaching the ventral profile, anus projecting slightly; gas bladder large, pigmented, lying below 6th–8th abdominal vertebrae, reduces in size around 12–13 mm becoming constricted in the middle; liver at first rectangular but

A



16 mm SL

B

22 mm SL

Fig. 60. *Bothus ocellatus,* Eyed flounder. A. Larva, 16 *mm SL.* B. Larva, 22 *mm SL, eye nearly finished migration. (A, B, Jutare, T. V., 1962: fig. 11C, used with permission of author.)*

soon becoming tongue-shaped with the end of the tongue projecting under the intestinal coil in the vicinity of the anus.[12]

Pigmentation: Smaller individuals in this genus have a few pigment spots [12] but these are lost and the fish becomes transparent by 8–10 mm; [8] pigment spots located on the dorsal tentacle, on the caudal fin and on the dorsal and anal fin rays near the tail; eye also black; in addition to the black pigment, live or fresh material may have pale purple ovoid chromatophores which fade in as little as a week in alcohol; these chromatophores located in rows on the eyeballs, along the edges of each myotome and on all interneural and interhaemal spines; ones on the upper eye, opercular and pectoral fins larger and numerous.[17]

JUVENILES

Minimum size may be over 42 mm [8] or about 9 mm depending on where taken [17] and presence of suitable habitat for metamorphosis.[12]

Pigmentation: Colorless and transparent from metamorphosis to about 20 mm TL at which length adult coloration is assumed.[5,10]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Bothus robinsi Jutare, Spottail flounder

ADULTS

D. 78 [2,6]–90; [6] A. 59 [2,6]–68; [4,6] P. ocular side 8 [6]–12,[2] usually 10,[2,4] blind side 7–11, usually 9; [2] scales 62 [4]–77; vertebrae 10 + 26–28,[2,6] modally 10 + 27; [2] gill rakers 2–7 [6] + 5–10.[2]

Proportions as percent SL or HL: Body depth 62.0 [4]–76 SL,[6] decreasing with length; [4] head 22.0–31.0 SL,[6] decreasing with length; [4] eye 24–31 HL,[6] 6.3–8.7 SL, decreasing with length.[4]

Upper profile of head slightly concave in front of eyes in both sexes,[2] gape to or slightly beyond anterior edge of lower eye.[2,6] Scales weakly ctenoid on ocular side, cycloid on blind side of females, cycloid on both sides of males. Teeth conical, slender, sharply pointed and convex on outer face, two rows in upper jaw, outer row covered with skin, large, few and far between, inner row small, numerous, closely arranged; three rows in lower jaw, outer and middle rows as outer and inner rows of upper jaw, innermost with teeth folded inward. First pectoral fin ray of eyed side greatly elongate in males.[2]

Pigmentation: Smaller individuals with light and dark

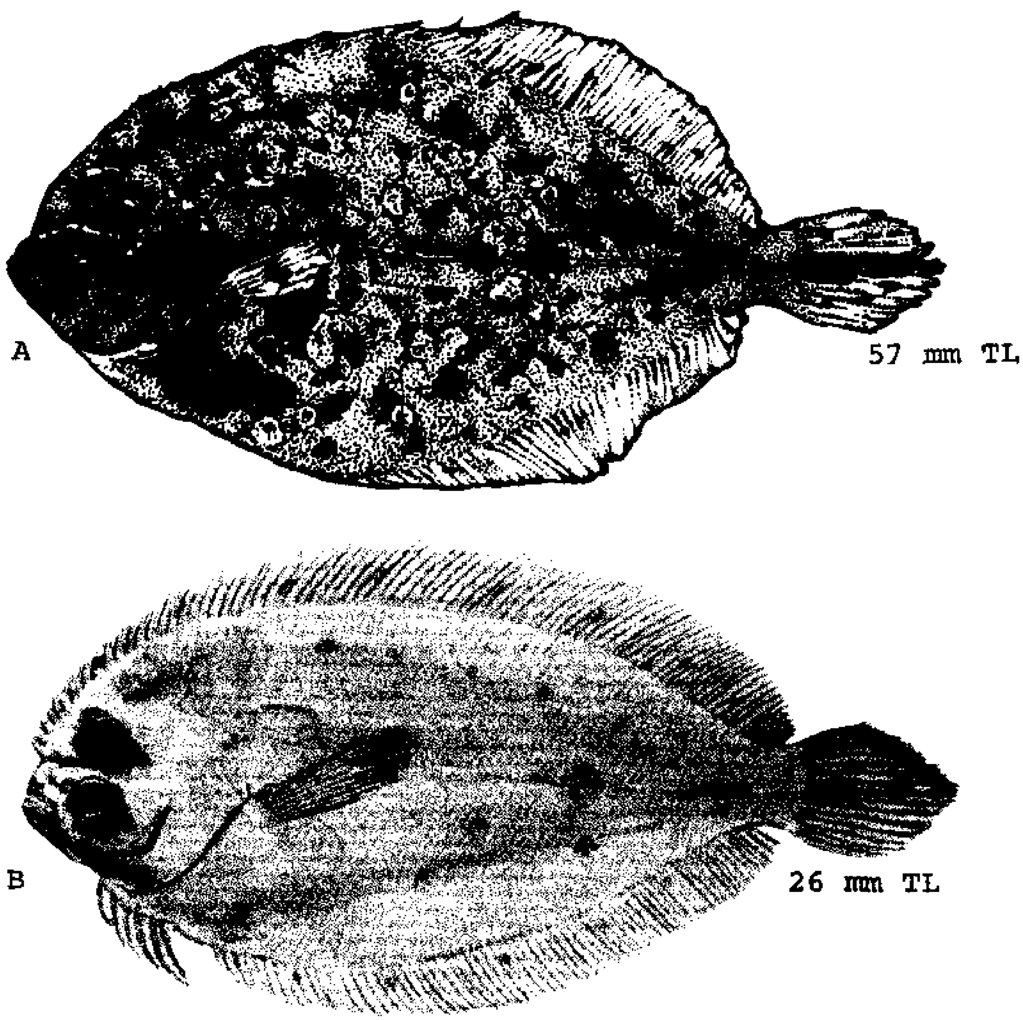

Fig. 61. *Bothus robinsi*, Spottail flounder. A. Large juvenile, 57 mm TL. B. Juvenile, 26 mm TL. (*A, Alperin, I. M., and R. H. Schaefer, 1965: 13, delineated by Tamiko Karr. B, Böhlke, J. E., and C. C. G. Chaplin, 1968: 216. © Academy of Natural Sciences of Philadelphia. Used with permission of authors and publishers.*)

ocelli on a ground of uniform brownish gray; larger examples generally darker and more uniform with the light ocelli less noticeable; three dark brown or black spots on the lateral line, the first forward on the body, the second about midway between the first and third, and the third on the caudal peduncle; dorsal and anal fins with dark spots, mostly lined up along the fin base; caudal fin with two dark spots on the center rays, one in front of the other, these sometimes connected,[4] apparently always present,[5] even in very small specimens; [6] a semicircular dark band a little past the center of the caudal fin.[4]

Maximum length: 22 mm SL.[3]

DISTRIBUTION AND ECOLOGY

Range: North Carolina to Florida, Gulf of Mexico, West Indies, Caribbean Sea, Atlantic coast of South America to Brazil,[6] also, the Bahamas [5] and New York.[1]

Area distribution: New Jersey; [8] probably occurs throughout the area but has not been recognized because of confusion with *B. ocellatus* (FDM).

Habitat and movements: Adults—shallow coastal areas on sand or mud,[4] also on patch reefs,[5] salinities 23.9 [7]–36.49 ppt; 12.0–30.0 C; [3] depths of 3.6 m [2] to 92 m [6] but usually in less than 55 m.[3]

Larvae—Planktonic, in the top 250 m, with most in the top 100 m.[2]

Juveniles—no information, but probably similar to adult habitat (FDM).

SPAWNING

Season prolonged, based on presence of ripe females, June to November,[8] may be longer (JWT).

EGGS

Unfertilized eggs about 2 mm with one oil droplet located on top of the yolk.[2]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

Metamorphose at 9–12 mm.

Except for the vertebral count being on the average one higher and the differences in fin ray counts, they are identical to *B. ocellatus.*[2]

JUVENILES

As with larvae, extremely difficult to separate from *B. ocellatus* prior to the assumption of the adult color pattern.[2] See account for *B. ocellatus.*

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Citharichthys arctifrons Goode, Gulf Stream flounder

ADULTS

D. 75–86; A. 58 [2]–67 [2,4,6] (one report of 68 as maximum [3]); C. total 16 [4] or 17,[1] 9+8; [4] P. ocular side 9–11,[2] 7 [4] blind side; V. 6 (JWT); scales 37–43; [2] vertebrae 10–11+26 [6]–28 [2] for a total of 36–39; [1,2] gill rakers 5+6–8; [2] teeth small,[6] $\frac{40}{25}$.[1]

Body proportions as percent SL or HL: Body depth 34–43 SL; head 23–38 SL; pectoral fin on ocular side 16–19 SL; eye 26–29 HL; upper jaw 27–32 HL.[2]

Body elongate; head small; [6] snout with a well developed horizontal osseus protuberance which increases with length; gape to a vertical through anterior portion of pupil.[2] Scales irregularly polygonal, cycloid, flexible, loosely arranged and deciduous; lateral line nearly straight. Pelvic fins scaly; dorsal fin origin on snout above anterior margin of upper eye; anal fin origin under axil of pectoral; caudal fin subsessile, triangular; pectoral fin insertion well below lateral line and close to gill opening; ocular side pectoral fin about twice as long as that of blind side; [4] males with blind side pelvic fin longer than other.[10] Females with a postanal extension of coelomic cavity containing the ovaries, visible through the translucent tissue.[3]

Pigmentation: Ocular side tan or brown with no obvious or noticeable markings.[2] Brownish white below.[10]

Maximum length: To 178 mm.[10]

DISTRIBUTION AND ECOLOGY

Range: Atlantic coast of U.S. from Georges Bank [2,10] to Florida; Gulf coast of Florida; Yucatan, Mexico.[2]

Habitat and movements: Adults—reported from a temperature range of 8–11.5 C; [5] reported as shallow as 22 m [1,2] but usually deeper than 37 m [1,8] and down to 682 m.[4]

Habitat and movement: Adult—reported from a temperature range of 8–11.5; [5] reported as shallow as 22 m [1,2] but usually deeper than 37 m [1,6] and down to 682 m.[4]

Larvae—6–11 C; [8] planktonic at 12–18 m but occasionally down to 50 m; usually found outside the 37 m contour line, but may be found as near shore as the 18 m contour.[1] More often close inshore off Long Island and Cape Hatteras than within the study area.[8]

Juveniles—one report of specimens at 137 m.[4]

SPAWNING

Most spawning takes place July through October, but may occur sporadically throughout the year, gravid females have been taken in August and September in the Chesapeake Bight.[1] Abundant small larvae indicate that most spawning within the Chesapeake Bight is between May and December.[8]

EGGS

Stripped unfertilized eggs almost transparent, spherical to slightly ovoid, with smooth surface; no apparent oil globule (probably present, JWT); .70–.82 mm diameter, average .74 mm.[1]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

Estimated 2 mm at hatching, yolk absorbed by 2.5 mm.

Abdominal region deep (deeper than *Etropus microstomus*, JWT) and laterally compressed; caudal region slender; head deep and laterally compressed. Eye heavily pigmented by 2.3 mm TL, fore-, mid-, and hindbrain distinctly outlined by 2.5 mm TL; gut coiled; gas bladder developed at 2.3 mm TL.[1]

Pigmentation: Melanophores scattered along the ventral body margin from angle of jaw to cleithrum, becoming less conspicuous with age; heavy concentrations of pigment occur over gas bladder, persisting until metamorphosis; between 2 and 3 mm TL may have a postanal band of pigment, which becomes a dorsal and an anal bar of pigment on the body margins about two-thirds distance from anus to notochord tip; melanophores appear scattered along ventral body margin from hindgut to tail tip. Scattered pigment may occur on finfold for 2 to 4 mm but in no set pattern.[1]

LARVAE

3 or 4 mm to 14 mm.

Total myomeres 34–35, caudal 17 at 9–10 mm; without the axial skeleton forward neural spines ossify first, followed by neural and haemal spines of the caudal region with development proceeding posteriorly, centra begin ossification in the posterior abdominal region with development proceeding both anteriorly and posteriorly; parts of maxillary, premaxillary, dentary and articular are ossified by 4 mm. Dorsal and ventral body outline become convex as metamorphosis approaches; eye roughly spherical with a ventral cleft apparent from 3.0 mm

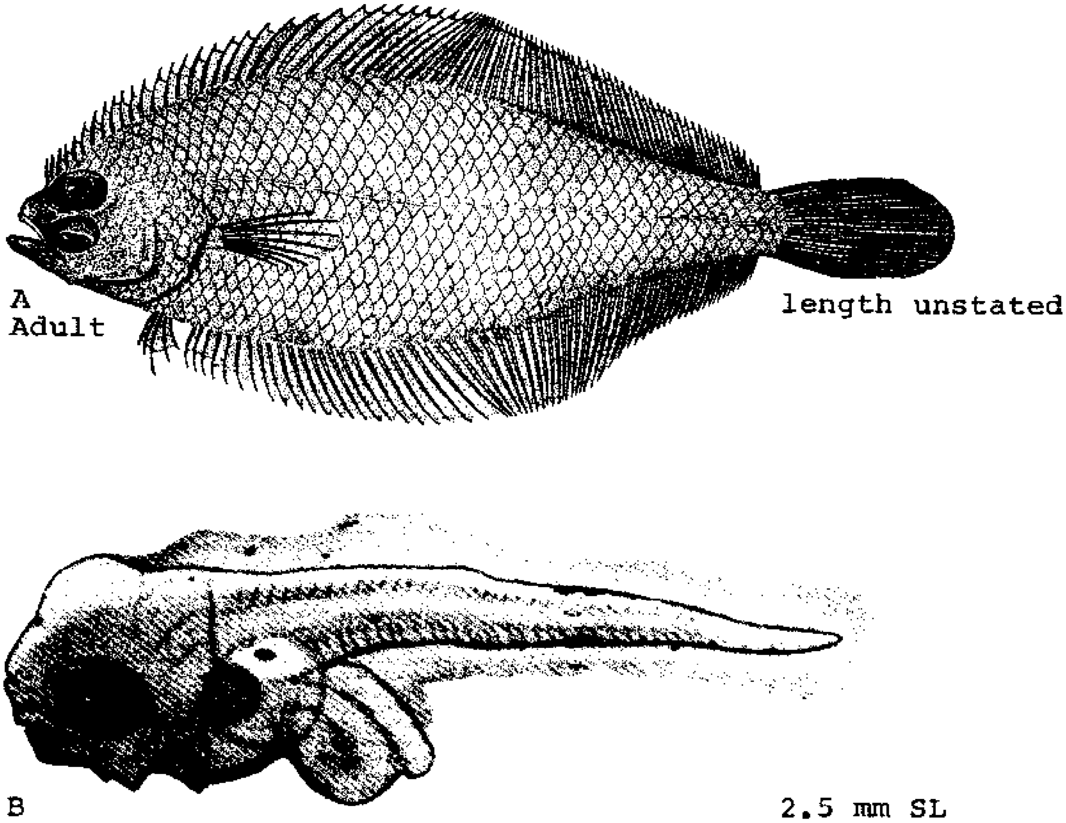

Fig. 62. *Citharichthys arctifrons*, Gulf Stream flounder. A. Adult, unstated length. B. Larva, 2.5 mm SL. (*A, Goode, G. B., and T. H. Bean, 1895: fig. 366a. B, Richardson, S. L., and E. B. Joseph, 1973: fig. 2.*)

to metamorphosis; otoliths not observable; nasal capsule evident by 3.0 mm. Dorsal fin rays begin ossification by about 5 mm with ossification starting in the middle and proceeding in both directions, dorsal fin ray complement complete by 8 mm, notch appears in dorsal fin at 4.0 mm, at 5 mm three elongated rays appear in the region of this notch and persist until metamorphosis; anal fin rays begin ossification by about 5 mm, beginning ossification in the middle and proceeding in both directions, full adult complement of rays by 10 mm; caudal fin rays begin ossification at 5–6 mm, complete complement by 9 mm; pectoral fins first appear at 5–7 mm, rays not forming until metamorphosis; pelvic fins form at 5–7 mm, ossification begins at 6 mm with the right fin completing formation before the left, complete complement of rays by 12 mm or more. By 10 mm right pelvic fin base located above body midline on blind side and anterior to left pelvic fin which is located on midline. Urostyle flexes at about 5 mm; anus shifts forward until it is adjacent to the base of the left pelvic fin and beneath the center of the gut cavity.[1]

Pigmentation: Clusters of melanophores are usually noticeable on the posteroventral angle of the lower jaw and at the tip of the cleithrum from about 5 mm throughout larval development. Pigment begins to appear over the brain at 6–7 mm. Concentrations of melanophores develop on the tips of the three elongated dorsal fin rays at about 8 mm. Additional melanophores appear over the dorsal surface of the hindgut at about 4 mm. Scattered melanophores occur along the ventral body margin from the cleithrum to the hindgut, this pigment becoming less concentrated at the pelvic fin bases after they form (5–7 mm); concentrations of pigment over the ventral part of the gut cavity increase with age with several diffuse melanophores appearing near the end of the hindgut by 8–10 mm. Pigment becomes noticeable at the tip of the pelvic fin by 5–6 mm. As the larva approaches metamorphosis one to three prominent pigment spots appear along the proximal margin of the interneural musculature, after which a general increase in pigmentation along the myosepta of the eyed side occurs. In the tail region a distinct horizontal pigment bar ap-

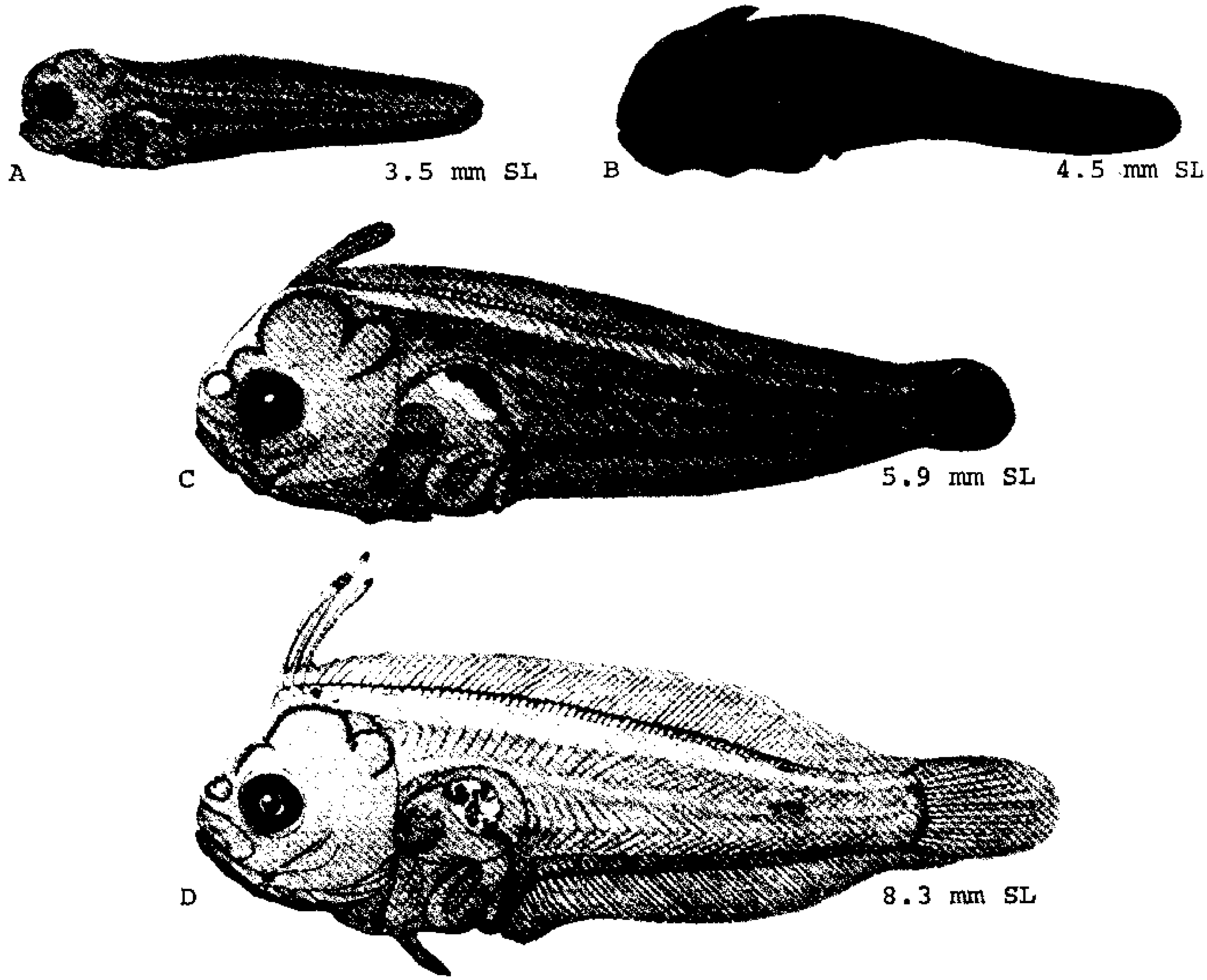

Fig. 63. *Citharichthys arctifrons*, Gulf Stream flounder. A. Larva, 3.5 mm SL. B. Larva, 4.5 mm SL. Anterior dorsal rays beginning to elongate. C. Larva, 5.9 mm SL. Notochord flexed. D. Larva, 8.3 mm SL. Elongated anterior dorsal rays separate distally, pigmented near tips. *(A-D, Richardson, S. L., and E. B. Joseph, 1973: fig. 5.)*

pears intermediate to the dorsal and anal bars by 4–5 mm. The three postanal pigment bars remain until metamorphosis. Pigment scattered along the ventral body margin from hindgut to tail tip shifts to distal margin of the interhaemal musculature; by 10–11 mm two clusters of melanophores develop along proximal margin of the interhaemal musculature between hindgut and ventral horizontal pigment bar; these clusters increase in prominence until metamorphosis. By about 5 mm internal pigment spots appear along dorsal surface of notochord immediately above intermediate postanal pigment bar, remaining apparent until metamorphosis. Along proximal margin of interneural musculature, several, usually 3, clusters of pigment become prominent by 12–13 mm, two between abdominal region and dorsal postanal pigment bar and one posterior to dorsal bar. Pigmentation increases along myosepta of body on eyed side as metamorphosis proceeds. Melanophores begin to delineate caudal fin base by about 10 mm and later appear scattered over the fin. Pigmentation appears on the dorsal and anal fins first as clusters and then scattered throughout.[1]

JUVENILES

Minimum size about 14 mm SL.

Gas bladder disappears during metamorphosis and is

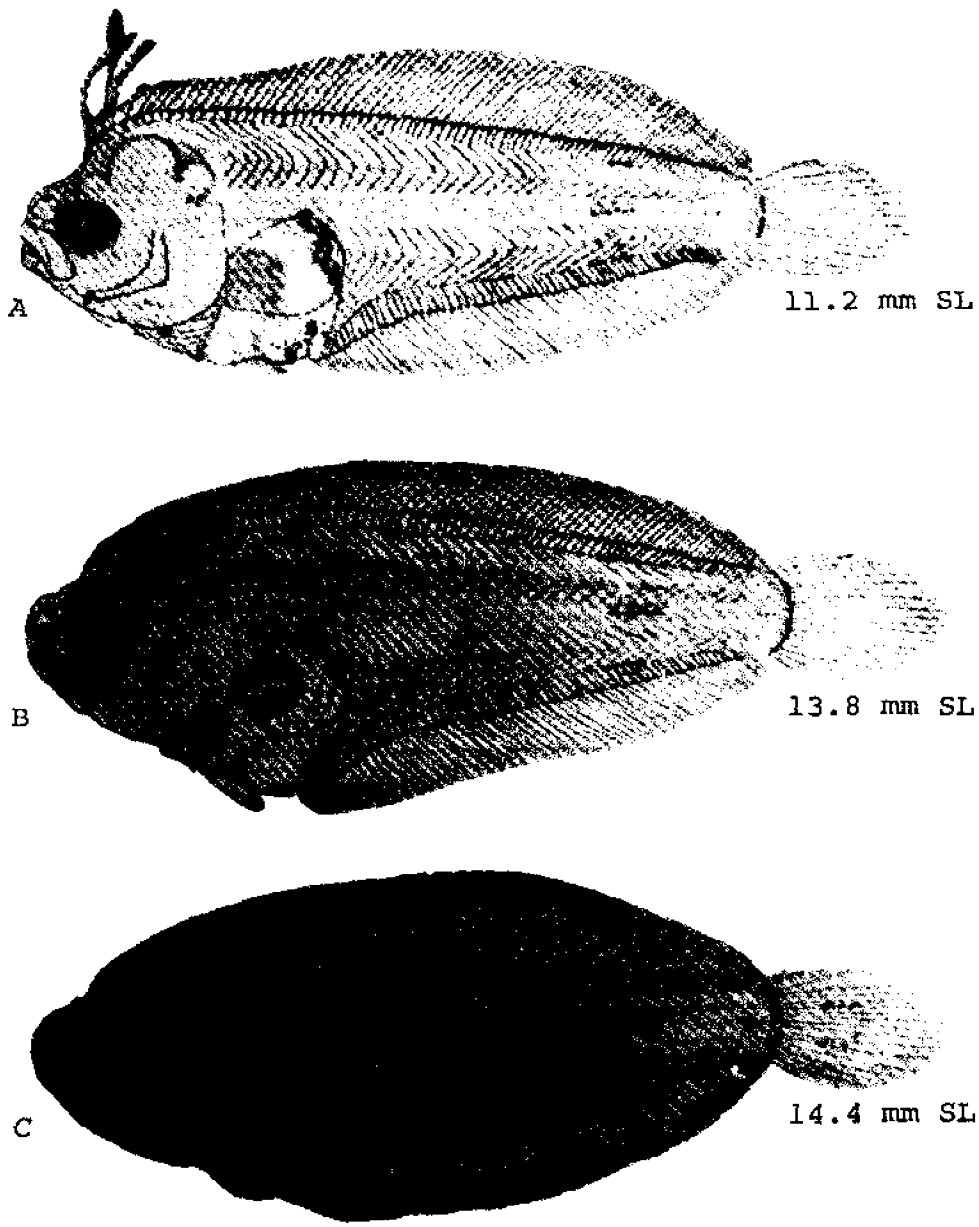

Fig. 64. *Citharichthys arctifrons*, Gulf Stream flounder. A. Larva, 11.2 mm SL. Notch through which eye will migrate forming. B. Larva, 13.8 mm SL. Right eye migrating, anterior dorsal rays no longer elongated. C. Larva, 14.4 mm SL. Eye almost finished in its migration. (*A-C, Richardson, S. L., and E. B. Joseph, 1973: fig. 6.*)

A

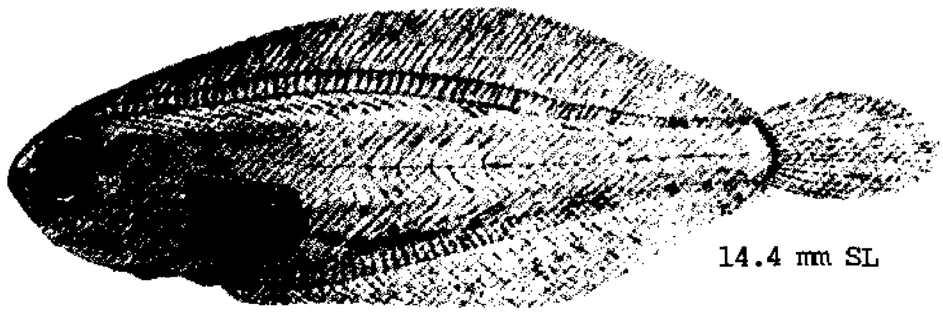

Fig. 65. *Citharichthys arctifrons,* Gulf Stream flounder. A. Juvenile, 14.4 mm SL. (*A, Richardson, S. L., and E. B. Joseph, 1973: fig. 6C.*)

absent in juveniles.

Pigmentation: At metamorphosis, amount of pigment on head increases; after metamorphosis a general darkening appears over brain, on lips and later over operculum. Pigmentation over the gut cavity increases greatly after metamorphosis and pectoral and pelvic fins become dotted with melanophores. The amount of pigment lining myosepta tends to decrease on body and increase in interneural and interhaemal regions. Pigmentation appears along lateral line of both sides. In females the pigmentation increases over ovarian cavity.[1]

GROWTH

No information.

AGE AND SIZE AT MATURITY

About 50 mm SL.[1]

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Citharichthys spilopterus Günther, Bay whiff

ADULTS

D. 75 [3,10]–84; A. 56 [3]–63; [6] C. 17, 9+8; [4] P. ocular side 9–10; scales 41 [3]–50; [6] vertebrae 10+23–25; [3] gill rakers 3 [21]–5 [3,15] + 9–15,[10] moderate.[3]

Proportions as percent SL or HL: Body depth 41–51 SL; head length 26 [3]–30.6 [5] SL; ocular side pectoral 13.8–17.0 SL; eye 13.4 [18]–25 HL; upper jaw 31 [3]–40.1 [18] HL.

Body moderately elongate, much compressed; [13] head profile slightly concave; [3] mouth large, jaw strongly curved, lower jaw slightly included; [10] gape extending to a vertical through posterior portion of pupil.[3] Teeth small,[10,13] in a single row, anteriorly a little enlarged,[6,13] anterior teeth widely set, posterior ones closely set.[6] Scales small,[15] finely ctenoid on ocular side,[13,15] cycloid on blind side,[15] subquadrangular on lateral line; lateral line nearly straight, gently ascending anteriorly.[6] Dorsal fin origin above anterior nostril of blind side; [3] anal fin origin slightly posterior to the bases of the pectoral fins; [10] fin rays scaley.[6]

Pigmentation: Ocular side greenish brown with dark spots; [5,10] a few dark blotches along the base of dorsal and anal fins; [10] fins shaded and mottled with gray; one obvious blotch on caudal peduncle.[5]

Maximum length: To 200 mm TL.[5]

DISTRIBUTION AND ECOLOGY

Range: New Jersey to Gulf coast in U.S.; also West Indies. Caribbean Sea, and Atlantic coast of South America to Brazil.[5,13]

Area distribution: New Jersey.[11,12]

Habitat and movements: Adults—very shallow water on mud, frequently among mangroves.[5,14] No clear pattern of movements (FDM). Seem to move offshore in winter in Mississippi; [19] in Louisiana inshore all year but most common in summer.[1] In Texas present in fall and winter in waters less than 11 m but absent in spring and summer,[2] absent or rare inshore from October to April; [8] in estuaries in Georgia May to November.[17] Euryhaline [7] but said to prefer higher salinities,[14] reported from 0 ppt [9,16] to 37 ppt [18] with a tendency to be in lower salinities only at higher temperatures; 5.0 C [16]–35 C,[18] reported to die at 6 C; [20] found down to 73 m.[3]

Larvae—in Cape Fear River estuary, North Carolina January to May (JWT).

Juveniles—over mud near mangroves; prefers higher salinities; while not usually entering brackish outlets [14] capable of tolerating down to between 2.0 and 4.9 ppt; in Cape Fear River estuary January to May (JWT); 4.9–10 C lower range, 25.0–29.9 C upper range [16] (data precision not adequate for closer estimation, FDM).

SPAWNING

No information.

EGGS

No information.

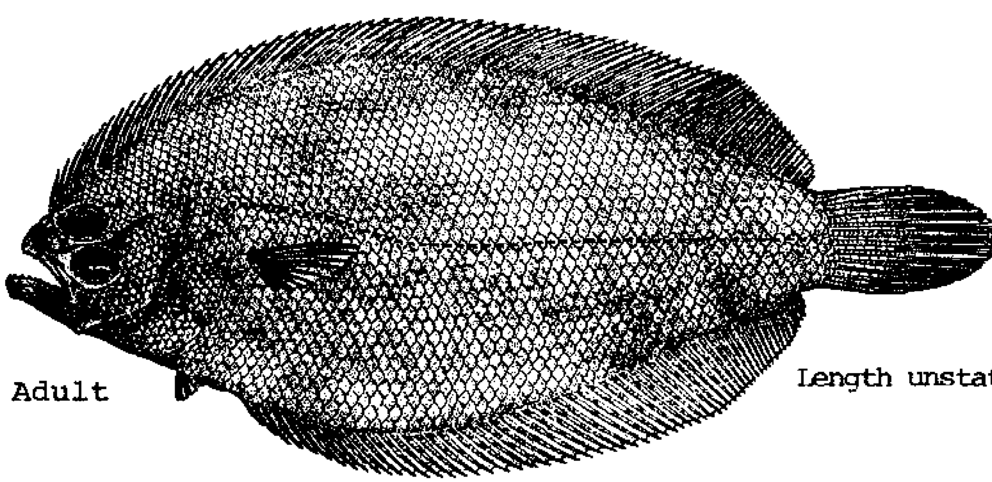

Fig. 66. *Citharichthys spilopterus*, Bay whiff. Adult. (*Goode, G. B., and T. H. Bean, 1895: fig. 370.*)

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Etropus crossotus Jordan and Gilbert, Fringed flounder

ADULTS

D. 75–87;[3,7,12] A. (55[5]) 58[3,7,12]–68;[3,7] P. ocular side 8–10, blind side 7–9;[3] V. 6;[8] scales 41[3,5]–48;[8] vertebrae 9[5]–10[3,7]+25;[3,7,8] gill rakers 4–5[3]+6–9,[3,13] moderate length;[13] teeth small, uniserial, reduced or wanting in upper jaw on eyed side,[5] strongly incurved;[8] no vomerine teeth.[10]

Body proportions as percent SL or HL: Body depth 50–58 SL; head 20–25 SL; eye 22–28 HL; upper jaw 21–27 HL.[3]

Body elliptical,[5] dorsal and ventral profiles about equally curved, strongly compressed; head short with a very short snout;[5,8] upper profile of head distinctly concave, nearly straight in young;[13] mouth small,[5,10] strongly oblique;[5] gape to a vertical through anterior edge of eye or slightly beyond.[3,13] Scales large,[5,8] thin,[10] deciduous,[3,10] with no secondary squamation,[3] ctenoid on eyed side,[5,8,10] cycloid on blind side;[5,8] lateral line nearly straight.[5,10] Dorsal fin origin a little in advance of upper eye; anal fin origin a little behind vertical from base of pectoral fins; caudal fin rounded[5] or double truncate;[10] pelvic fins small; pectoral fins moderate, one on ocular side longer than that on blind side.[5]

Pigmentation: Ocular side brown,[3] grayish brown[4] or olive brown,[10] either uniform,[3] with a single darker spot on caudal peduncle[4] or blotched.[10] Dorsal and anal fins with rows of dark spots in the central part of each fin[4] or mottled;[3,10] caudal fin edged in black on some large specimens;[3] pectoral and pelvic fins on left side spotted.[10]

Maximum length: To at least 169 mm TL.[11]

DISTRIBUTION AND ECOLOGY

Range: Chesapeake Bay south through the West Indies to Trinidad and Venezuela and possibly southern Brazil[11] (if synonymous with *E. intermedius*, JWT), also throughout Gulf of Mexico, probably on Caribbean coast of Central America.[11]

Area distribution: Lower Chesapeake Bay.[5,11]

Habitat and movements: Adults—over mud,[4] sand and crushed shell with an accumulation of silt[11] and along sandy shores;[5] inshore all year but most common in the fall in Louisiana;[1,12] least common or absent in January in Texas;[2,3] most common in fall and early winter with a sudden reduction in numbers in January with a low point in June in southeastern U.S.[6] but with a peak in June off Pinellas County, Florida.[14] Occur between 4.4 and 36.7 ppt salinity;[9] 5–34.9 C,[12] reported to die in the range 4.0–7.0 C;[16] shore[5] to 64 m[3,11] but seldom deeper than 33 m.[11]

Larvae—no information.

Juveniles—in Georgia, along beach in 0.5 ppt.[17]

SPAWNING

Summer,[7] March to June off Florida,[22] May in Cape Fear River estuary (JWT) or winter in Mississippi.[15]

Fecundity: About 155,000 eggs in a 99 mm female.[11]

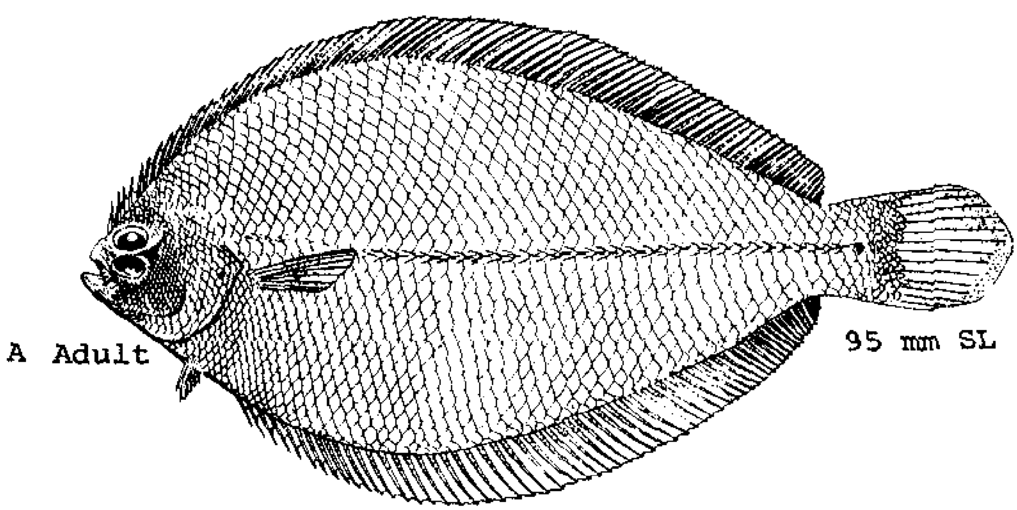

Fig. 67. *Etropus crossotus*, Fringed flounder. A. Adult, 95 mm SL. (*Topp, R. W., and F. H. Hoff, Jr., 1972: fig. 9.*)

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

JUVENILES

No information.

GROWTH

No information.

AGE AND SIZE AT MATURITY

Females mature at about 89 mm, males mature at about 91 mm.[11]

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Etropus microstomus (Gill), Smallmouth flounder

ADULTS

D. 67[2,10]–82;[2] A. 50[2,10]–63;[2] C. 4–5–4–4, total 17,[1] 4–6–5–3, total 18[3,8] or more probably 9+8;[11] P. ocular side 9–12, blind side 8–9;[2] V. 5 (JWT); scales 37[2]–45;[2,10,12] vertebrae 10+24–25;[11] gill rakers 3–6+4–7,[2] short, stout;[10] teeth $\frac{6}{16}$.[1]

Body proportions as percent SL or HL: Body depth 43–51 SL; head 21–27 SL; eye 22–30 HL; upper jaw 24–38 HL.[2]

Body ovate;[12] head small,[7] upper profile a little concave; snout blunt;[8] mouth small, very oblique;[12] gape to a vertical through anterior part of eye.[2,10] Teeth small, close-set, larger in front.[3,8] Scales large,[3,8] deciduous,[2] ctenoid on eyed side except near lateral line, cycloid on blind side,[8] secondary squamation present.[2,3,8,10] Lateral line nearly straight (JWT). Dorsal fin origin above front rim of orbit,[3,8] caudal fin rounded, pectoral fin on ocular side much larger than that of blind side.[8]

Pigmentation: Ocular side uniform brown[2,10] or reddish brown[3,8] sometimes spotted or blotched;[12] dark pigmentation between orbits and around mouth;[2] a series of distinct, obscure, blackish blotches along basal portions of anal and dorsal fins.[4]

Maximum length: To 152 mm.[7]

DISTRIBUTION AND ECOLOGY

Range: New England to Florida and into the Gulf of Mexico.[9]

Area distribution: Chesapeake Bight;[1,5] Delaware River estuary;[6] lower Chesapeake Bay.[4]

Habitat and movements: Adults—on mud bottoms;[17] taken inshore in Delaware River estuary from June to October; 7[13]–32.5 ppt salinity; 13.8[13]–22 C;[6] to 91 m[2] but usually less than 37 m.[1]

Larvae—8–17 C;[9] 0–12 m, modal depth 2 m; most specimens taken within the 37 m contour;[1] mostly over depths of 15–45 m;[9] found out to 183 m contour,[1,9] occasionally found out to water 340 m deep because of current transport.[9]

Juveniles—on sandy bottom.[11]

SPAWNING

South of Chesapeake Bay spawning may be year round but peaking in July through October.[9]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

Estimated 2 mm SL at hatching to 2.5 mm SL.

Body deep, laterally compressed; head also deep and laterally compressed, caudal region slender; eye pigmented by 2.3 mm SL; fore-, mid-, and hindbrain distinctly outlined by 2.5 mm SL; nasal capsule evident at 3 mm; finfold surrounding body from head around tail tip to the anus; gut coiled; anus posterior to main visceral mass.[1]

Pigmentation: A few melanophores scattered along lower jaw and on ventral body margin from lower jaw angle to cleithrum; most conspicuous abdominal pigmentation on the gas bladder; melanophores line ventral body margin from cleithrum to hindgut; at 2.3 mm SL a band of pigment about two-thirds the distance from anus to notochord tip.[1]

LARVAE

3–4 mm SL to 10–12 mm SL.

Caudal 17 at 7–8 mm SL;[1] myomeres 11+24 (NSS); vertebral ossification begins with abdominal neural spines, proceeding to caudal neural and haemal spines, centra begin in posterior abdominal region, ossification proceeding in both directions; premaxillary, maxillary, dentary and articular begin ossification by 4 mm SL. Eye roughly spherical with a ventral cleft from 3 mm SL to metamorphosis. Left otolith obvious by 10–11 mm SL. Incipient dorsal fin rays begin to appear in center at 4 mm SL, ossification proceeding in both directions, complete complement by 8 mm SL; incipient caudal fin rays appear at 4 mm SL, full complement by 7 mm SL; pectoral fin rays not appearing until metamorphosis; pelvic fin buds at 5 mm SL, rays at 5–6 mm SL, right complete before left, full complement by 11–12 mm SL. Urostyle flexed upward at about 5 mm SL. Anus shifts forward until it rests adjacent to the base of the left pelvic fin and lies beneath center of gut cavity.[1]

Pigmentation: Pigment on ventral side of head increases to 8.9 mm SL, decreasing afterward. A group of melanophores usually noticeable on posteroventral angle of lower jaw and sometimes on tip of cleithrum; melanophores over hindbrain and midbrain single or in groups

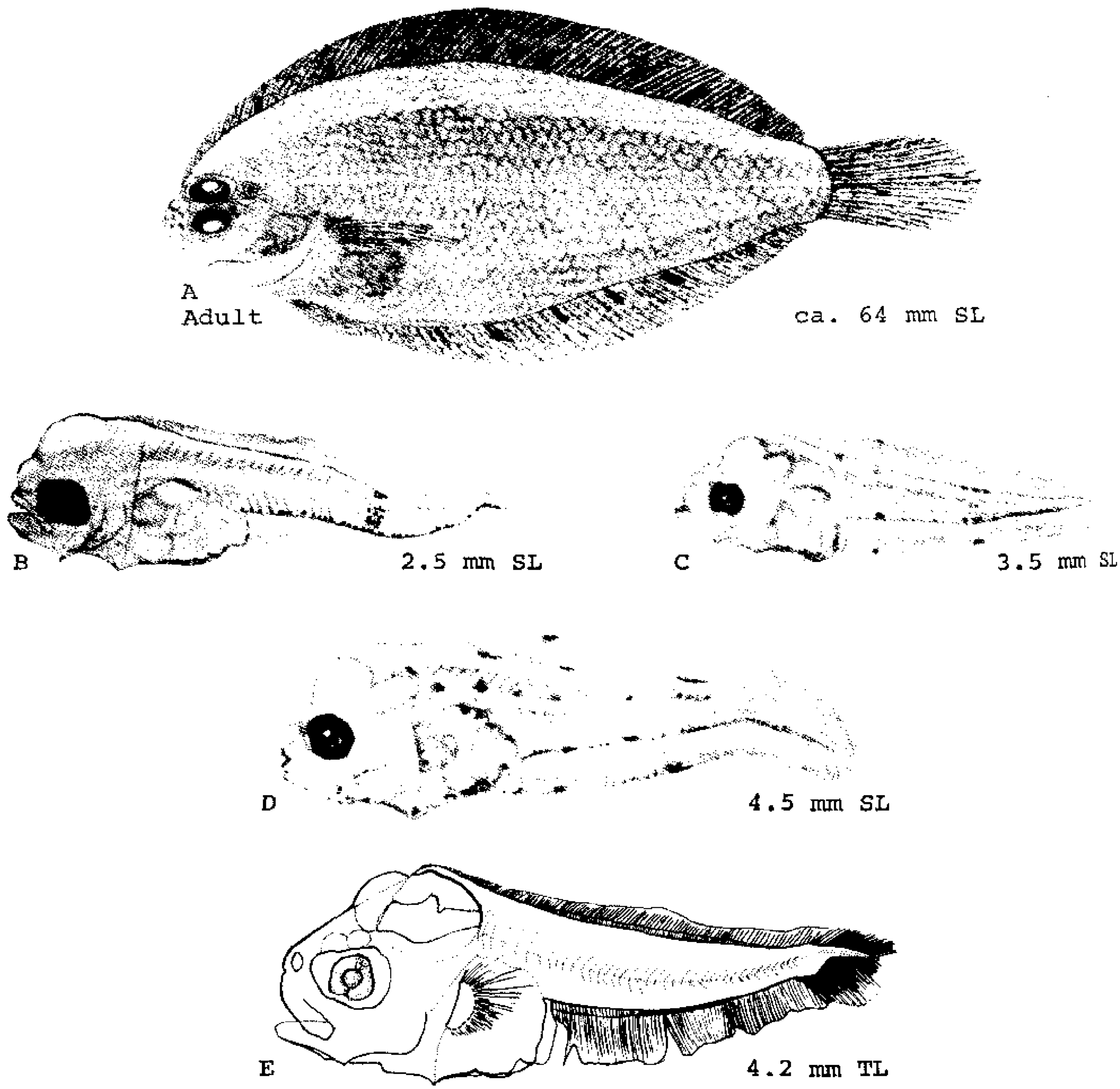

Fig. 68. *Etropus microstomus*, Smallmouth flounder. A. Adult, ca. 64 mm SL. B. Larva, 2.5 mm SL. Postanal pigment band noticeable. C. Larva, 3.5 mm SL. Head proportionally shorter. D. Larva, 4.5 mm SL. Pigmentation noticeably increased. E. Larva, 4.2 mm TL. Pectoral fin well developed. (*A-D, Richardson, S. L., and E. B. Joseph, 1973: figs. 3, 8. E, Scotton, L.,* et al., *1973: 108.*)

from 3.5 mm SL to metamorphosis. Specimens longer than 8 mm SL with scattered melanophores around snout and upper jaw and on the operculum. By about 8 mm SL an internal pigment spot seen beneath lobe of hindbrain; at 10–11 mm SL a single stellate melanophore on operculum anterior to base of pectoral fin. After pelvic fin begins to form (5–7 mm SL) melanophores no longer line ventral body margin at the fin base, but increase in concentration under gut. Several diffuse melanophores, the number increasing with age, appear over end of hindgut at about 3 mm SL. One or two stellate melanophores visible on pectoral fin near its ventral origin; scattered melanophores appear on distal margin of pelvic fins after formation. Two or three characteristic internal pigment spots along dorsal surface of notochord above gut cavity at about 4 mm SL, remaining until metamorphosis. A pigment spot appearing on dorsal body margin above gut cavity at about 3 mm SL, persisting to metamorphosis, but moving onto the proximal margin of the interneural musculature. By 3 mm SL, sometimes before, the postanal pigment band becomes two horizontal lines of pigment along ventral and dorsal body margins and a third line appears along notochord; all three lines persisting until metamorphosis. Melanophores lining ventral body margin from gut to notochord tip, shifting to distal margin of interhaemal musculature as development proceeds. One prominent ventral pigment spot appearing at 3 mm SL one-third distance from hindgut to postanal pigment bars. A second prominent ventral spot appearing at about 4 mm SL halfway between first spot and

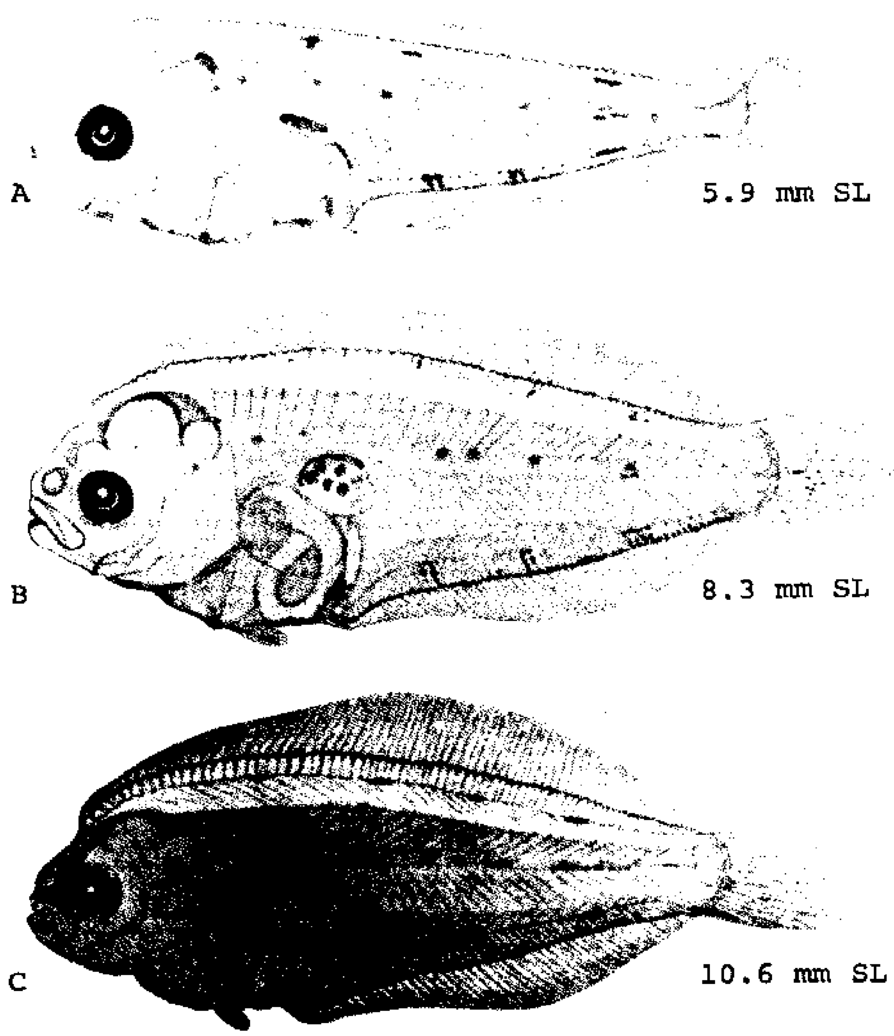

Fig. 69. ***Etropus microstomus***, Smallmouth flounder. A. Larva, 5.9 mm SL. Notochord flexed. B. Larva, 8.3 mm SL. Dorsal insertion moved forward to a position over the eye; pelvic fins formed. C. Larva, 10.6 mm SL. First traces of the dorsal notch through which the eye will migrate. (*A-C, Richardson, S. L., and E. B. Joseph, 1973: figs. 3, 4.*)

postanal bars. At location of these two ventral pigment spots and ventral postanal pigment bar, melanophores form several vertical lines along septa of interhaemal musculature from proximal to distal margin, appearing at about 5 mm SL, persisting until metamorphosis. Along dorsal body margin one prominent spot appearing at about 3 mm SL and another by 6–7 mm SL between gut cavity and tail tip, opposite those on ventral margin. Up to metamorphosis these spots may appear as a cluster of melanophores, a horizontal line or a vertical line extending onto interneural musculature. An increase in pigmentation along myosepta on eyed side as metamorphosis approaches.[1]

One to three prominent melanophores may be seen on distal edges of finfold dorsally and ventrally on larvae up to about 5 mm SL. Scattered melanophores may be present along ventral finfold up to fin formation (6–8 mm SL); scattered melanophores form at edge of caudal fin base as soon as it forms (5–6 mm SL), later melanophores

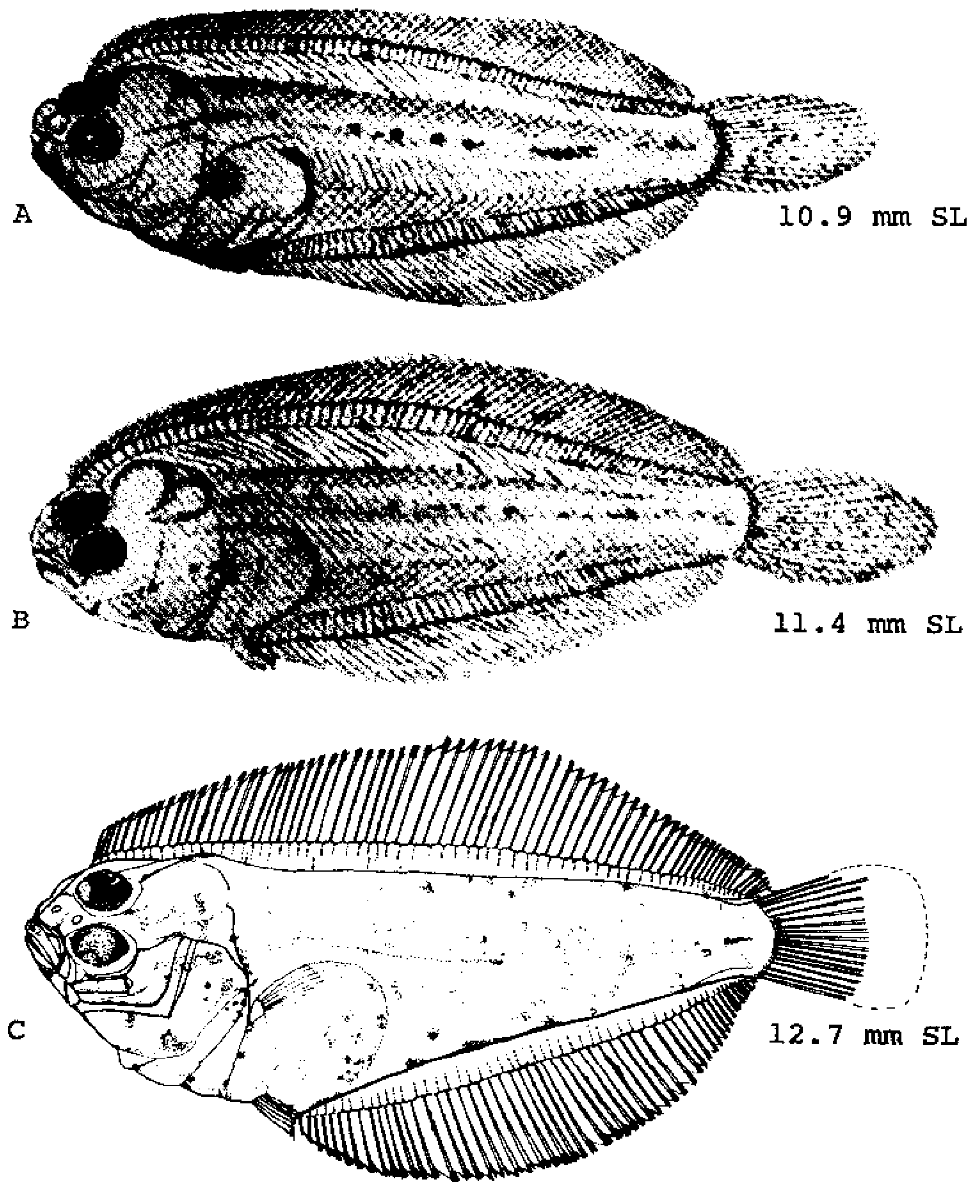

Fig. 70. *Etropus microstomus*, Smallmouth flounder. A. Larva, 10.9 mm SL. Eye migrating. B. Juvenile, 11.4 mm SL. Eye migration complete; pectoral fin reduced in size. C. Juvenile, 12.7 mm TL. Upper eye shifted posteriorly somewhat. *(A-B, Richardson, S. L., and E. B. Joseph, 1973: fig. 4. C, original drawing by Nancy Schenk Smith.)*

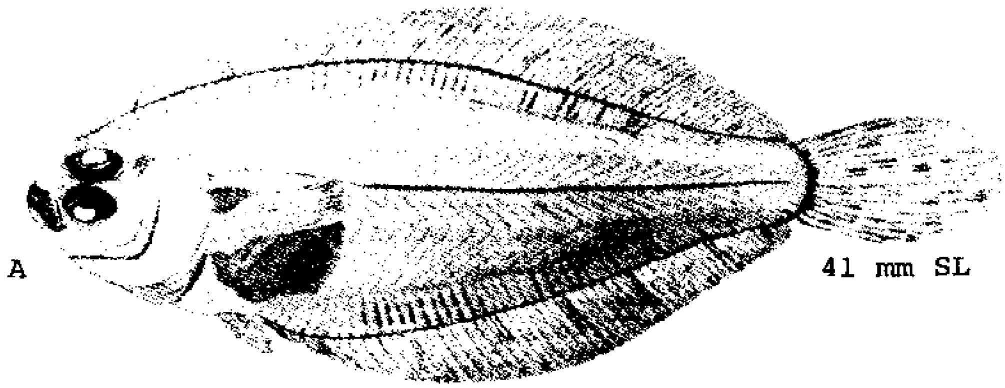

Fig. 71. *Etropus microstomus*, Smallmouth flounder. A. Juvenile, 41 mm SL. (*Richardson, S. L., and E. B. Joseph, 1973: fig. 7.*)

becoming scattered throughout fin and sometimes delineating fin base. Melanophores begin to dot both dorsal and anal fins at about metamorphosis, first appearing in groups and later scattering throughout.[1]

JUVENILES

10–12 mm SL to 50 mm SL;[1] myomeres 11 + 25 (NSS).

Pigmentation: After metamorphosis head pigmentation becomes less pronounced; a general darkening occurs on lips and over brain, later snout darkens and opercular pigmentation increases. Gut cavity becomes darkened on eyed side; pigmentation increases on pectoral and pelvic fins; pigmentation disappears along myosepta on interneural and interhaemal regions. Concentrated blotches of pigment along proximal portions of dorsal and anal fins. Caudal fin base delineated by pigment. Pigmentation along interneural and interhaemal myosepta and along lateral line increases.[1]

GROWTH

Average standard length increases from 62 mm in late July to 84 mm by mid-October.[7]

AGE AND SIZE AT MATURITY

Mature by 50 mm SL.[1]

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Hippoglossina oblonga (Mitchill), Fourspot flounder

ADULTS

D. 71[1,2,9]–86;[1,2,9,21,23] A. 58–72[1,2,9] (rarely to 76[21,23]); C. 1+9+8+0–1, total 18–19;[12] P. 10–12;[1,2] scales about 95,[2,23] more than 90,[21] scale rows over straight portion of lateral line 63–81;[1] vertebrae 11+30–31;[2,9,12] gill rakers 1–2[2] (plus 2–5 rudiments)+7–10[1,2] (usually 8 or 9), moderately long,[2] thick.[1,21]

Body proportions as percent SL or HL: Body depth 38–44

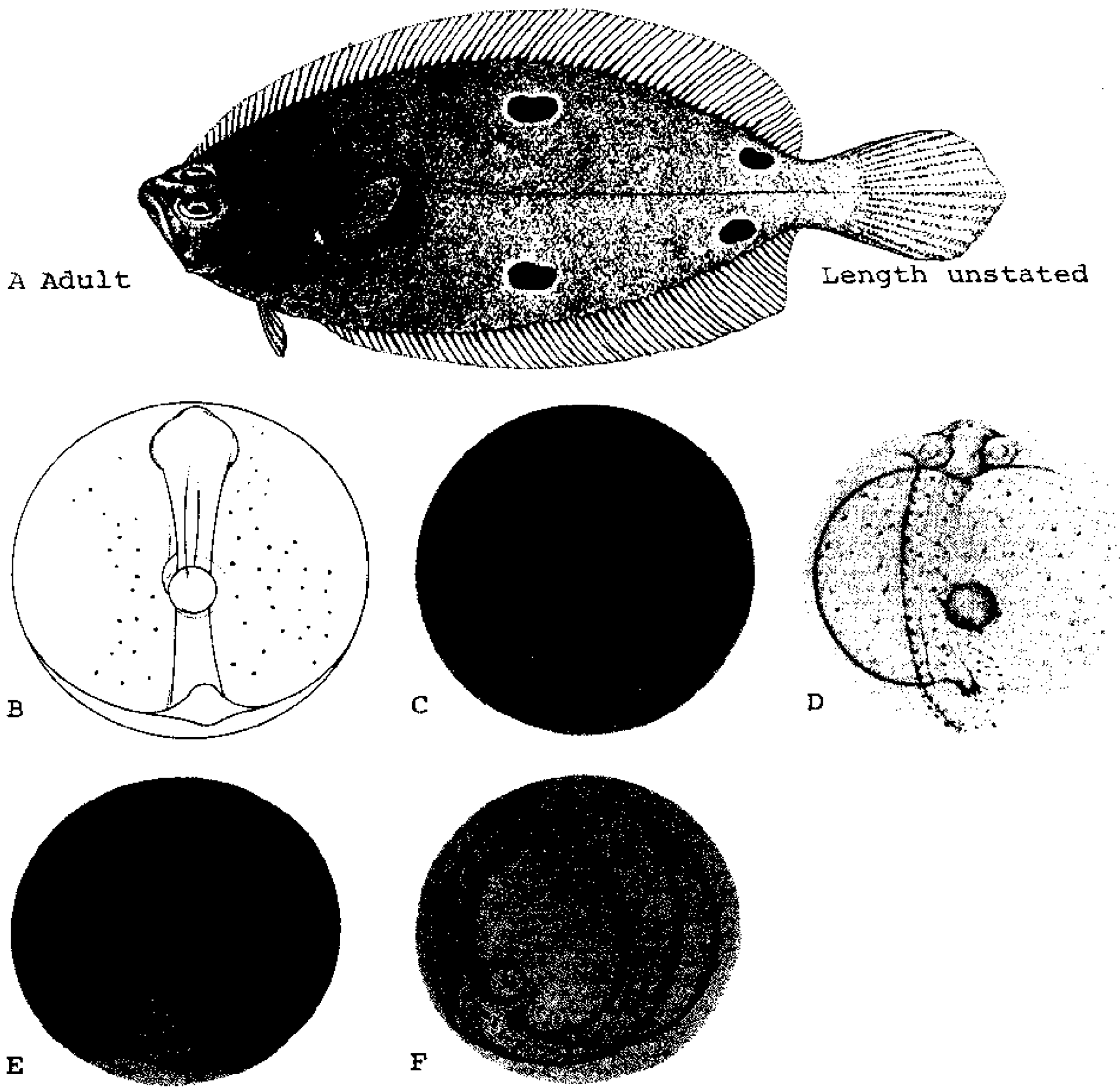

Fig. 72. *Hippoglossina oblonga*, Fourspot flounder. A. Adult, length unstated. B. Egg, diameter unstated, at blastopore closure. C. Egg, diameter unstated, chromatoblasts present but unpigmented. D. Egg, diameter unstated, melanophores pigmented, yellowish pigment on body. E. Egg, diameter unstated, xanthophores round in tail, yellow pigment diffuse in rest of body. F. Egg, diameter unstated, just prior to hatching, yellow pigment becomes reddish brown in finfold, in patches, that of body remains yellow and diffuse, melanophores dendritic. (*A, Storer, D. H., 1867: pl. 31. B-F, Agassiz, A., and C. O. Whitman, 1885: B, delineated by Elizabeth Ray Peters.*)

SL; head 25–29 SL; eye 25–30 HL; upper jaw 44–50 HL.[2]

Body oblong, much compressed;[6,21] head short,[21] upper profile straight or slightly concave above eyes;[23] sharp ridge between eyes; mouth terminal, large, with projecting lower jaw; gape to a vertical through posterior edge of pupil.[1,2] Teeth in upper jaw numerous, small, close-set, with 4–5 canines anteriorly;[6,21] lower jaw with 7–8 teeth on both sides, largest in front.[6] Scales small, cycloid; lateral line similar to that of *P. dentatus* (JWT). Origin of dorsal fin behind[1,2] or over anterior edge of orbit;[6,21] caudal fin moderate and rounded; anal fin origin under tip of gill cover; pectoral fins small, rounded, base behind and slightly below tip of gill cover.[6]

Pigmentation: Ocular side brownish gray[23] or brownish,[1,2,23] generally mottled,[8,23] having 4 conspicuous ocelli,[1,2,23] each surrounded by a pinkish area,[23] anterior two spots near midpoint of body and near dorsal and ventral margins, posterior two just in front of the caudal peduncle.[1,2,23]

Maximum length: To about 400 mm.[1,17]

DISTRIBUTION AND ECOLOGY

Range: Georges Bank to Tortugas, Florida.[2,8,22]

Area distribution: Chesapeake Bight,[7,9,14,22] Delaware River estuary,[10] Chesapeake Bay.[19]

Habitat and movements: Adults—reported from winter temperatures of 8.9–13.9 C. Reported from shallower depth in north and greater depth in southern parts of range;[1,2] Massachusetts down to 27 m,[1,2] Rhode Island 9–27 m,[16] New York to depths greater than 37 m, North Carolina 37–91 m,[1,2] Florida 201–402 m,[5] usually deeper than 274 m;[1,2] greatest reported depth 437 m.[1]

Larvae—planktonic,[4,15] from temperatures of 6.2 C[22]–20.5 C;[4,15] occur to edge of continental shelf, but most common on middle shelf.[22]

Juveniles—no information.

SPAWNING

Location: Occurs at depths of 35–80 m.[22]

Season: Late spring[3] (May[1,20,22]) through summer[3,4,8,9,15] and fall (through October[22]) or perhaps into December.[20]

Temperature: Seems to occur at 6.2–9.0 C[22] but eggs found up to 20.0–22.4 C.[4]

EGGS

Buoyant;[1,20] .91–1.12 mm,[11] mean diameter .95 mm,[13] .98 mm[1,18] or 1.04 mm;[11] nonadhesive;[20] oil droplet single,[1,11,15,17] .10[4,15]–.19 mm,[17] mean diameter .15 mm.[13,18]

EGG DEVELOPMENT

At 21.1 C: 36 hours after fertilization—tail bud formation; at this time melanophores first appear as minute flecks rather uniformly scattered over embryo and, to a lesser extent, over yolk mass. Xanthophores at 42 hours after fertilization, remain prominent through later development, first appear as diffuse blotches with irregular locations of appearance.[11]

Temperature unstated: Prior to free tail bud diffuse yellow as traces on body; immediately after free tail bud small round black dots appear. Considerable development of xanthophores prior to hatching. At about hatching small round black dots few in number and nearly evenly spread over yolk sac, head and body; finfold over anterior portion of caudal peduncle with a few melanophores. Xanthophores more numerous and 2–3 times larger than melanophores; yolk sac with only a few xanthophores and none in ventral half; oil globule with 1 or 2 xanthophores and 10 or more melanophores. Xanthophores evenly distributed on head and trunk, stopping short in front of end of tail. Dorsal finfold xanthophores form a single row along margin of the middle third; halfway between vent and tail tip a cluster of xanthophores above and one below the axis of the tail; only 2 or 3 xanthophores in ventral finfold between vent and paired caudal clusters.[13]

Incubation period 8 days at 10.6–13.3 C,[1,20] 54 hours at 21.1 C.[11]

YOLK-SAC LARVAE

Hatching size 2.7–3.2 mm.[11]

At 24 hours after hatching, yolk sac greatest length 32.2% TL; yolk sac to vent distance 6.4% TL; postanal length 50.0% TL; greatest body height 17.7% TL.[13]

Body comparatively long at hatching.[13] Anus opening at margin of finfold.[11,13]

Pigmentation: At hatching, melanophores dendritic[11,13] or granular, evenly scattered over head, trunk and yolk sac;[11] xanthophores in dorsal finfold form brownish yellow blotches and whole body with a diffuse yellow hue.[13] Halfway between vent and tail tip melanophores slightly more dense so as to suggest a vertical band extending onto both finfolds;[11,13] rest of finfold and tail unpigmented[11] or with one blotch near tip of tail. Yellow pigment much reduced at 80 hours after hatching.[13] Eye becoming more pigmented as yolk absorption progresses,[11] may have blue pigment at 60 hours after hatching.[13]

LARVAE

4.0 mm[8] SL to 11 or 12 mm.[15]

Vertebral centra not all ossified by 7.0–8.5 mm SL, 11 + 30–31 at 9 mm SL; body becomes rounded in dorsal and ventral outline at 11.0–12.0 mm SL; right eyes begin migration at 10.0–11.0 mm SL. Dorsal fin rays become evident at 6 mm SL, complete complement by 10.0 mm, origin moves anteriorly and slightly toward blind side at 11.0–12.0 mm SL; anal fin rays evident at about 6 mm SL, complete complement by 10.0 mm SL; caudal fin rays evident at about 6 mm SL, formation complete by 7.0–8.5 mm SL; pectoral buds present at 4.0–5.5 mm SL; pelvic fins not present at 4.0–5.5 mm SL, incipient rays at 10.0 mm SL, complete formation by 11.0 mm SL; finfold evident around body at 4.0–5.5 mm, remnants at 6.0 mm SL. Scale formation begins at 11.0–12.0 mm SL; notochord flexion at about 6 mm SL; anus less than halfway back on body at 4.0–5.5 mm SL; shifts further forward at 5.5–7.0 mm SL, continuing to move forward at 11.0–12.0 mm SL.[8]

Pigmentation: 4.0–5.5 mm SL—most conspicuous marking a pigment band extending from dorsal to ventral body margin, sometimes onto finfold, halfway between anus and notochord tip, posteriority, tail devoid of pigment. Melanophores also concentrated over hindgut and along ventral body margin from hindgut to pigment band; some pigment scattered over head, around mouth, along ventral margin of gut cavity and over viscera; eye heavily pigmented.

5.5–7.0 mm SL—postanal pigment band spreads anteriorly and posteriorly, but still concentrated between hindgut and tail tip. More pigment scattered over gut region and along ventral body margin posterior to hind gut.

7.0–8.5 mm SL—pigment covers entire caudal region from hindgut to near base of caudal fin.

8.5–10.0 mm SL—pigment over caudal region still emphasized. Additional pigment covering viscera, melanophores scattered over anal and pelvic fins.

10.0–11.0 mm SL—pigment more heavily concentrated on caudal region, except for a small unpigmented zone

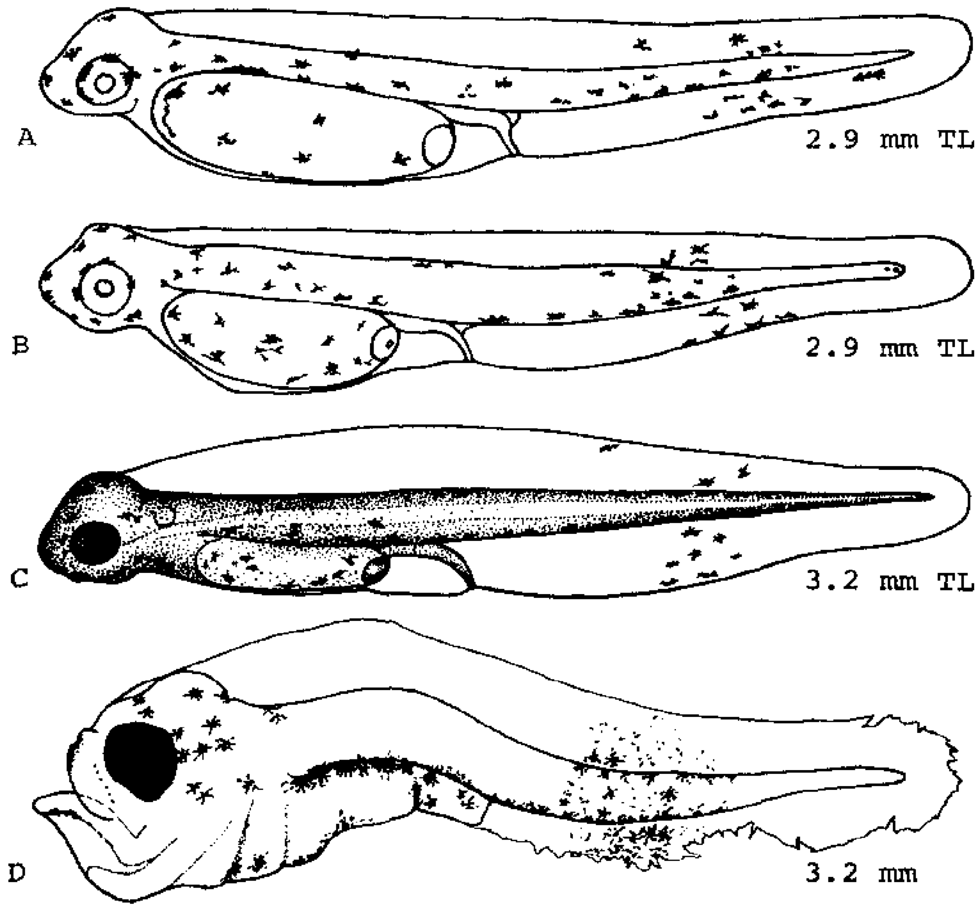

Fig. 73. *Hippoglossina oblonga*, Fourspot flounder. A. Yolk-sac larva, 2.9 mm TL. B. Yolk-sac larva, 2.9 mm TL, showing variation in head shape and pigmentation. C. Yolk-sac larva, 3.2 mm, yolk nearly absorbed. D. Larva, 3.2 mm. (*A-C, original drawings by A. J. Lippson. D, original drawing by O. Sette.*)

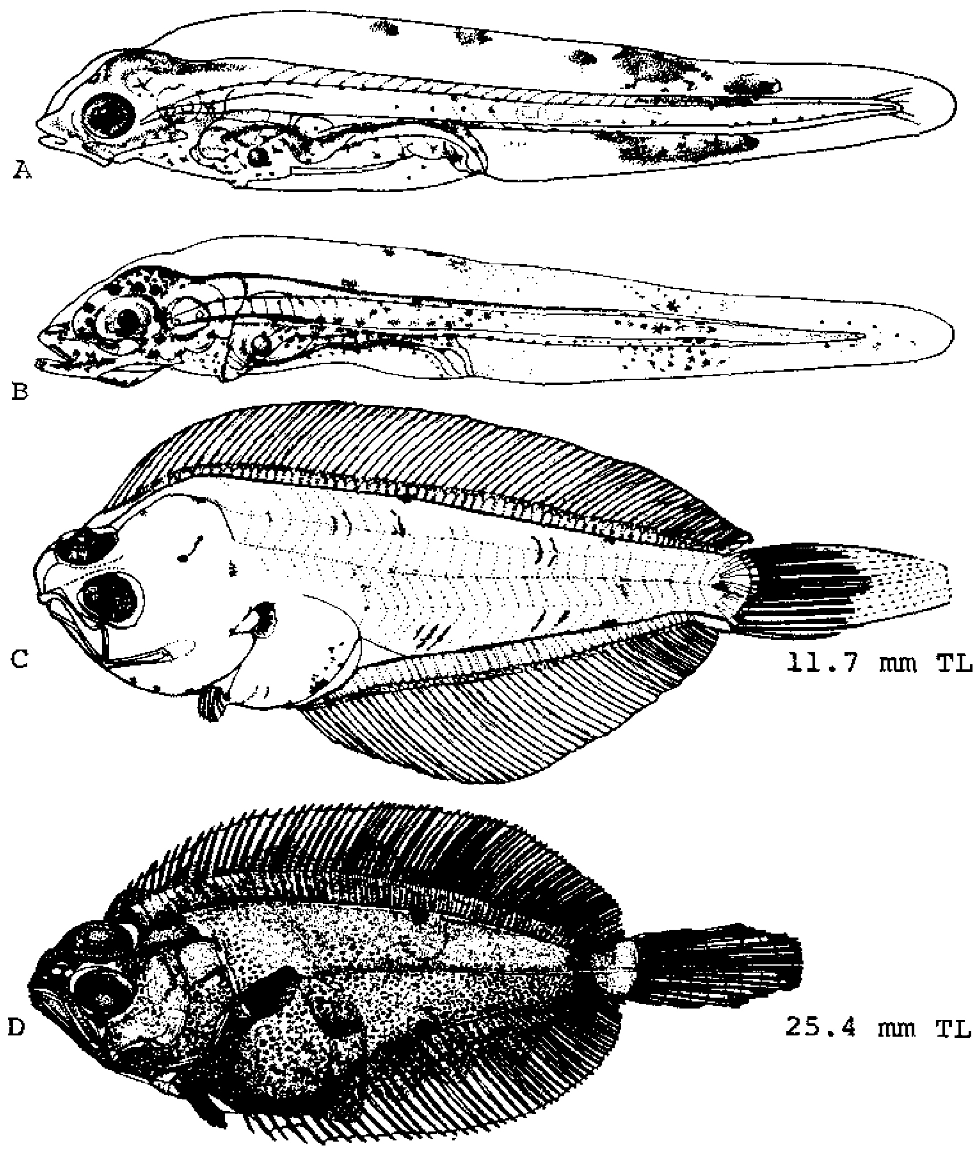

Fig. 74. *Hippoglossina oblonga*, Fourspot flounder. A. Larva, length unstated, listed as 60 hours old but more developed than the other 60 hour figure. B. Larva, length unstated, "somewhat older than" previous figure. C. Larva, 11.7 mm TL, eye approaching final position. D. Juvenile, 25.4 mm TL. (*A-B, Agassiz, A., and C. O. Whitman, 1885: pl. 15; delineated by Elizabeth Ray Peters. C-D, original drawings by Nancy Schenk Smith.*)

at base of caudal fin; melanophores have spread dorsally and ventrally along bases of dorsal and anal fins and out onto both fins.

11.0–12.0 mm SL—blind side begins fading, caudal portion of body remaining noticeably darker than head and abdominal region. The anterior pair of four characteristic spots becomes prominent (not yet ocellated) near body midpoint; several other dark areas seen near dorsal fin behind head and near anal fin over hindgut; this pigment concentration coincides with scale formation. Additional melanophores appear along proximal portions of dorsal and anal fins.[8]

JUVENILES

No information.

GROWTH

80–160 mm by September of first year.[1]

AGE AND SIZE AT MATURITY

No information.

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Monolene sessilicauda Goode, Deepwater flounder

ADULTS

D. 92–107; A. 76[1]–84;[1,5] P. 11–14 on ocular side, no pectoral fin on blind side; scales 88–94,[1] about 72 of these on the straight portion of the lateral line;[5] vertebrae 10–11[1] + 35–36;[2] 8–10 moderate length gill rakers on lower limb.[1]

Body proportions as percent HL or SL: Head 17–22 SL; body depth about 30–39 SL;[1] eye about 25[5] to 32 HL; upper jaw 25–30 HL.[1]

Body thin;[5] gape to a vertical through anterior part of eye.[1] Scales on ocular side subcircular with an irregular outline, ctenoid; on blind side oval, cycloid.[5] Lateral line on ocular side curved over base and anterior two-thirds of pectoral fin. Fins with scaly bases; dorsal fin origin on snout even with the anterior margin of the lower eye; anal fin origin between tips of pelvic fins and under insertion of pectoral fins; caudal fin sessile, rounded; pectoral fin present on ocular side only; pelvic fins on median ventral line, equal in length.[5]

Pigmentation: Ocular side tan to brownish with several large blotches arranged as bands across body (banding is dependent on retention of body scales). When present, bands arranged as follows: anteriormost from nape across distal part of opercle; second under pectoral fin, third just in front of body midpoint; fourth just behind body midpoint; fifth before caudal peduncle. A large dark blotch on center of caudal fin (may appear as two bands) and several large blotches along dorsal and anal fin bases. Pectoral fin with light base, numerous black spots, and blotches forming crossbars on lower half of fin, upper half light.[1]

Maximum length: To 170 mm TL.[7]

DISTRIBUTION AND ECOLOGY

Range: Atlantic coast of U.S. from New England to Florida; Gulf of Mexico.[1,6]

Area distribution: Off New Jersey.[4,6]

Habitat and movements: Adults—reported in winter temperatures of around 10 C and from depths of 30 m[3] to 1318 m.[5]

Larvae—found near continental shelf edge.[6]

Juveniles—no information.

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

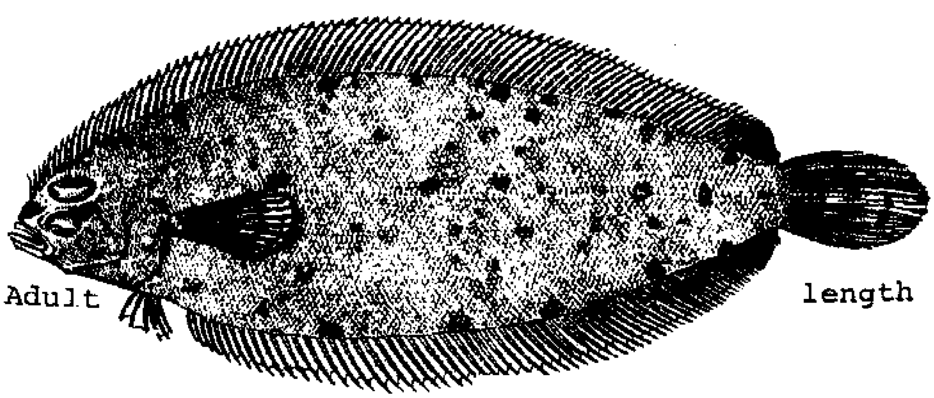
No information.

YOLK-SAC LARVAE

No information.

LARVAE

Specimens 5.7 to 29.5 mm SL showed no evidence of impending metamorphosis.[2]



A Adult length unstated

Fig. 75. *Monolene sessilicauda*, Deepwater flounder. A. Adult, length unstated. (*Goode, G. B., and T. H. Bean, 1895: fig. 357a.*)

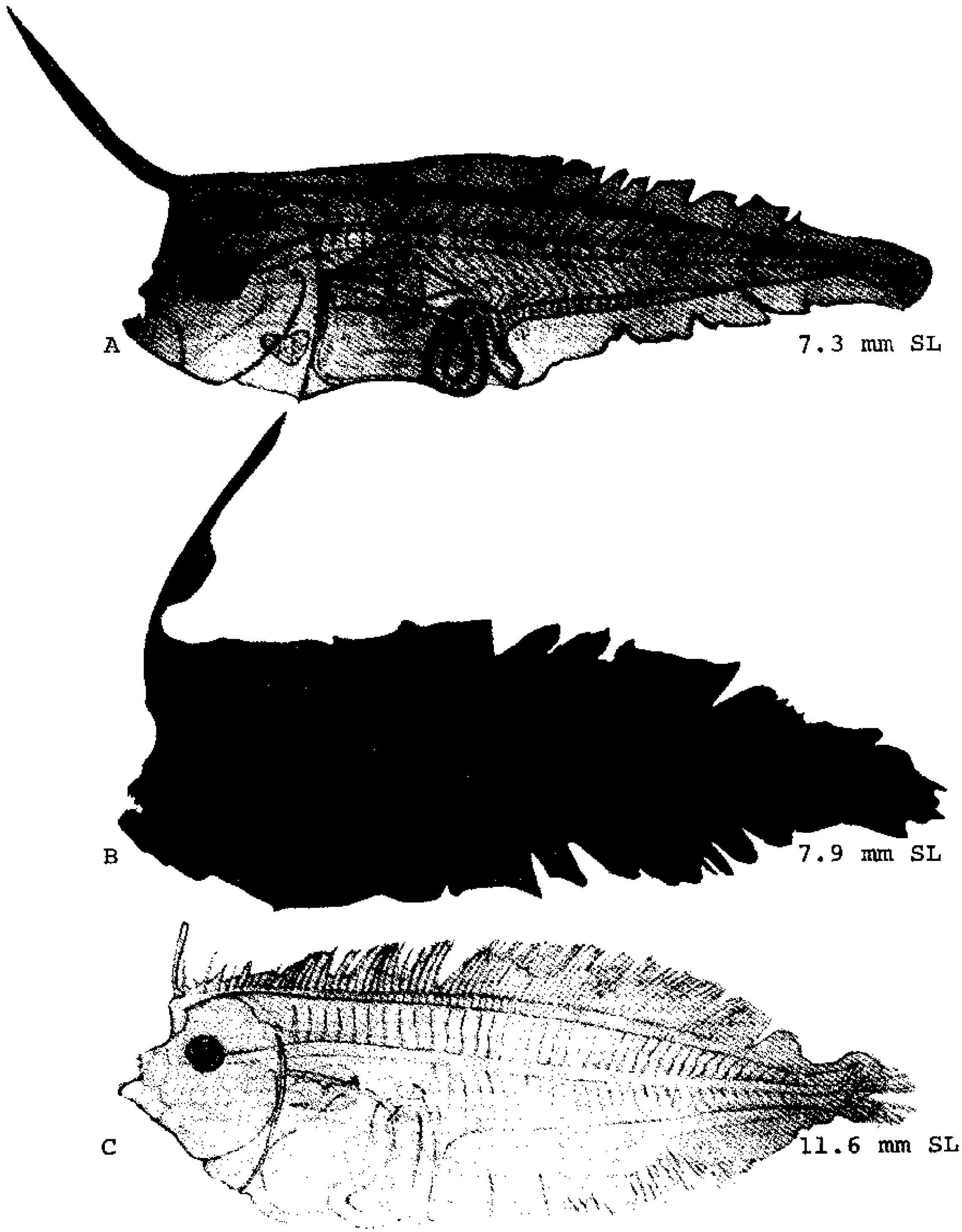


Fig. 76. *Monolene sessilicauda*, Deepwater flounder. A. Larva, 7.3 mm SL, rays in finfold beginning formation. B. Larva, 7.9 mm SL, most rays in vertical fins formed. C. Larva, 11.6 mm SL; notochord flexed, dorsal tentacle broken. (*A-C, Futch, C. R., 1971: figs. 2, 3, 4.*)

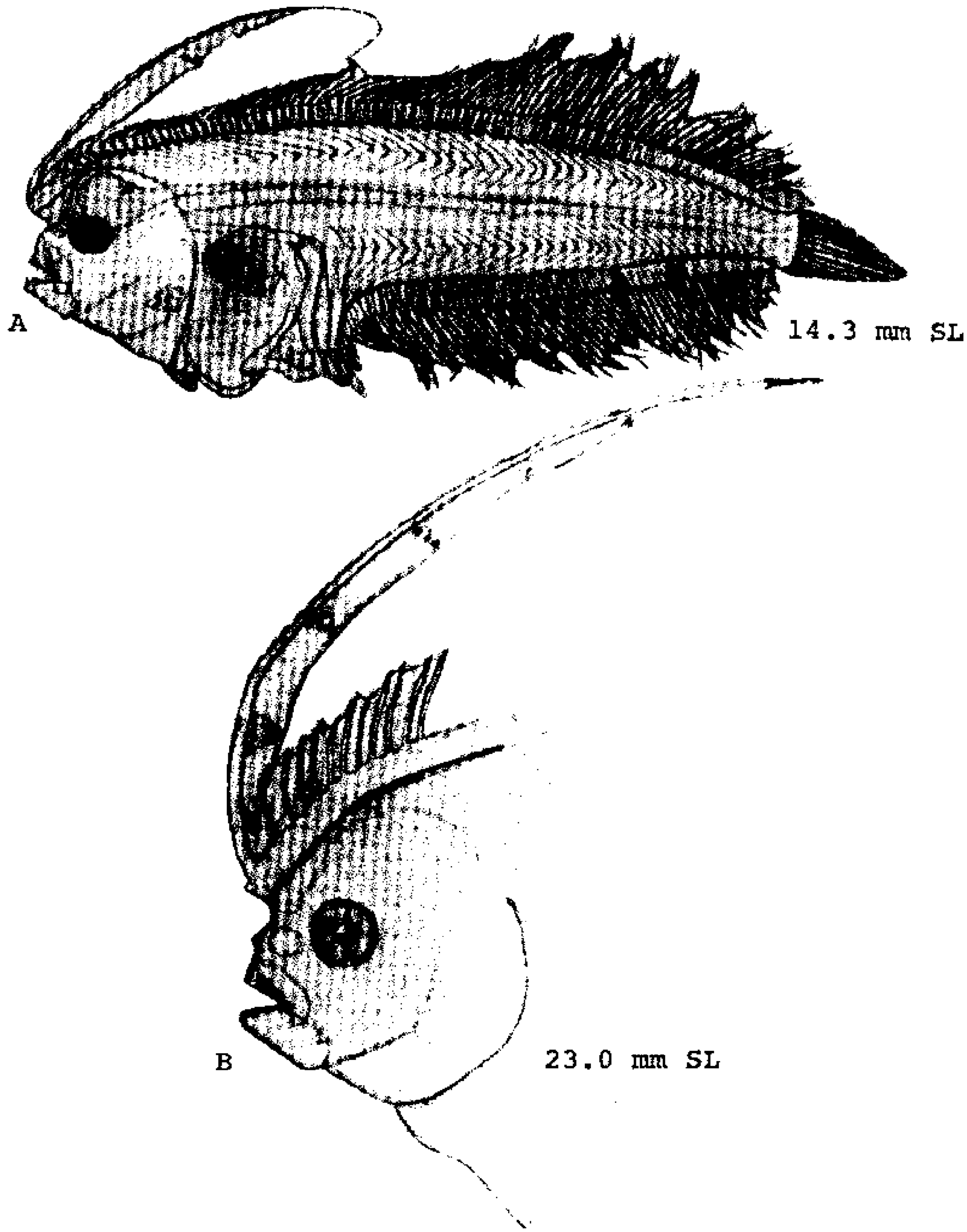


Fig. 77. ***Monolene sessilicauda***, Deepwater flounder. A. Larva, 14.3 mm SL, fin rays complete or very nearly so. B. Head of larva, 23.0 mm SL, showing development and pigmentation of dorsal tentacle. (*A-B, Futch, C. R., 1971: figs. 5, 6.*)

Preanal myomeres 10, postanal myomeres 35–36; vertebrae 10+35–36, neural and haemal arches appear between 7.3 and 7.9 mm SL with all vertebrae and associated arches present by 14.3 mm SL.[2]

Postanal length 57–69% SL; body depth 58–75% SL.[2]

Body compressed, diaphanous; teeth variable in size and abundance; nasal capsule evident at 7.9 mm SL; tubular nostrils at 29.5 mm SL. First dorsal fin ray long, dorsal fin ray proliferation occurring between 7.3 and 7.9 mm SL; starting at mid-fin and diverging, full ray complement by 14 mm SL; anal fin begins at 7.3 mm SL with devel-

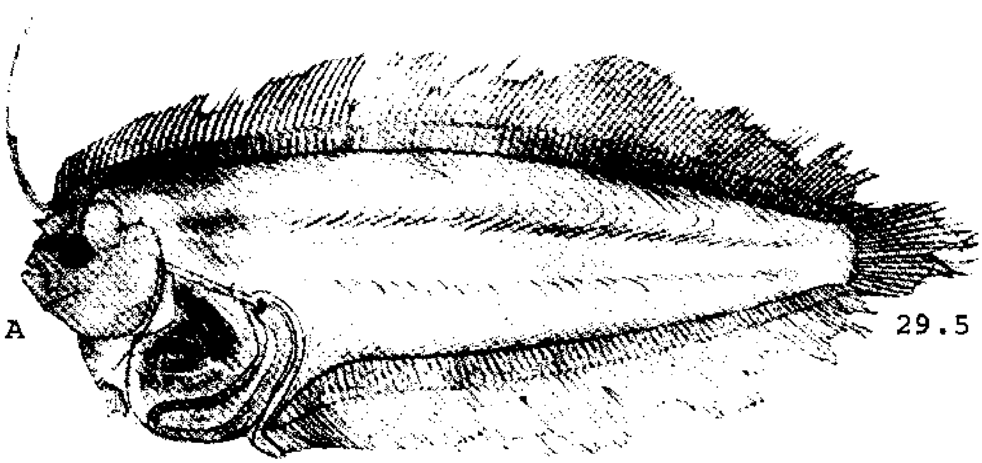


Fig. 78. *Monolene sessilicauda,* Deepwater flounder. A. Larva, 29.5 mm SL, membrane on dorsal tentacle degenerating. (*A, Futch, C. R., 1971: fig. 7.*)

opment proceeding posteriad; caudal fin ray formation starts between 7.9 and 11.6 mm SL, complete between 11.7 and 14.3 mm SL; pectoral fins small, fleshy based; not differentiated into adult form at largest size available; pelvic fins symmetrical, 6 rays, posterior to cleithral symphysis on long basipterygial cartilage, development occurring between 11.6 and 14.3 mm SL; notochord flexure between 7.9 and 11.6 mm SL. Gut with a single loop, rugate at 29.5 mm SL; gas bladder persisting in all sizes available; liver large, occupying most of body cavity anterior to gut.[2]

Pigmentation: Sparse, irregular; one specimen with melanophores on upper peritoneum; one with scattered melanophores over right side of neurocranium; one with seven areas of pigment on first dorsal fin ray and attached tissue sheath.[2]

JUVENILES

Still juveniles at 72 mm SL.

D. 96–102; A. 76–81; P. 12 on ocular side, 4–5 on blind side; scales about 120.[5]

Body depth about 33% SL; caudal peduncle depth about 7% SL; head 18% TL.[5]

Body thin, divided into 3 longitudinal tracts by depressions at the base of the rows of interspinous processes; mouth small with upper jaw somewhat hooked; lateral line straight on both sides. Dorsal fin inserted in advance of eyes; pectoral fins inserted near gill opening far below the lateral line, that on blind side much shorter than ocular side; pelvic fins on ventral margin. Scales small, thin, deciduous.[5]

Pigmentation: In life nearly colorless, translucent with three blackish longitudinal stripes or lines on the left side. The stripe running from the gill opening to the base of the tail less prominent than those present at the bases of the interspinous processes. On the blind side, both lateral stripes are present. Eyes black.[5]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Paralichthys dentatus (Linnaeus), Summer flounder

ADULTS

D. 80 [1,2,18,32]–96; [1,2,18] A. 60 [8,10,25,32]–75; [32] C. 1+9+8+0; [32] P. 11 [32]–13; [1,2] scales 91 [2]–108,[32] 61–73 in straight portion of lateral line; [8] vertebrae 10 [31]–11+30–31; [33] gill rakers 3–7 [1,2](usually 5 or 6)+13–18 (usually 15 or more),[2] long and slender; [7] 16–28 dentary teeth on ocular side.[3]

Body proportions expressed as percent SL or HL: Body depth 41 [31]–47 SL; [2] head length 24 [1,2]–34 SL (decreasing with growth); maxillary 12–16 SL [1] or 45–53 HL.[2]

Body moderately elongate, dorsal and ventral outlines about equally convex,[10] greatest depth at about midway in length, caudal peduncle deep, compressed; [7] head large, with a pointed snout,[7,10] upper profile straight; [32] interorbital flat; mouth large, oblique, the jaws somewhat curved; [7,10] gape to posterior margin of pupil by 125 mm SL,[1,2,7] to posterior margin of eye by 200 mm SL; [1,2,10] beyond posterior margin of eye at lengths greater than 300 mm SL.[1,2] Teeth large, pointed.[7,10] Scales small,[10] cycloid,[1,7,10,32] secondary squamation present.[7,32] Lateral line with short, prominent anterior arch.[10] Fins scaled,[23] origin of dorsal fin over or slightly in advance of upper eye; caudal fin rounded under base of pectoral fins; pelvic fins symmetrically placed under and behind margin of opercle.[10]

Pigmentation: Color variable depending on background, varying from nearly white through gray, blue, green, orange, pink and brown to almost black; [25] usually with 12–15 dark spots having white edges,[23] five of these spots arranged as two triangles with a common apex on the lateral line.[1,2,10]

Maximum size: To 900 or 950 mm SL [8,10,14,25,31] and to weights of 13.6 kg [1,23,25] to 13.8 kg.[16]

DISTRIBUTION AND ECOLOGY

Range: Atlantic coast of U.S. from Maine to Florida,[2,10] two stray specimens reported from Canada,[5] two others reported from Texas.[5]

Area distribution: Throughout the Chesapeake Bight,[2,14,18,20] within Chesapeake Bay [10,26] from Annapolis south.[26]

Habitat and movements: Adults—shore water [10] over sand,[1,17,17,21,25] hard bottoms,[1] mud,[1,19] grass [1,25] or around pilings; [25] also in tidal channels of salt ponds.[24] Adults migrate offshore during winter [1,10,17,19,21] or in more southerly waters may remain near shore; [9] very little summer movement; [19] apparently some individuals migrate great distances.[5] From fresh or nearly freshwater [4,6,23] to 37.0 ppt; [22] 6.6 C [20]–31.2 C; [22] summer, 4–36 m; winter, 36–183 m.[1,2]

Larvae—newly hatched, near the bottom, later appearing as plankton in upper layers; [1] possibly partially benthic in that when not actively swimming, they may drop down to the substrate; [29] 0.02–35.0 ppt salinity; 2–22 C; [30] early larvae concentrate at 22–57 m depth; mostly 22 to 83 km offshore but at times as much as 111 km.[29]

Juveniles—estuarine; [27,29] move into brackish or estuarine environments shortly after metamorphosis; [29] at about 125 mm SL they begin to move back to marine salinities,[1] may move into oceanic waters in summer months, overwinter in Pamlico Sound (ABP); 0.02–37 ppt salinity; 2–31.2 C.[27]

SPAWNING

Evidence indicates three nearly independent spawning populations, one north of Delaware Bay, another in the region of Virginia to Cape Hatteras, and a third south of Cape Hatteras.[29]

Location: Occurs during offshore migration [19] mostly at depths of 20–48 m [27] and at 22–61 km offshore off New Jersey and Delaware, 65 km offshore off Maryland and 9 to 19 km off North Carolina.[29]

Season: North of Chesapeake Bay, September to December, south of Chesapeake Bay, November to February.[27,29]

Temperature: Spawning occurs mostly between 12 and 19 C,[29] eggs abundant at 14.0 C.[27]

EGGS

Near surface; [29] spherical, transparent, with a rigid shell; diameter 0.90 [15]–1.13 mm,[5] mean of 1.02 mm; yolk amber and translucent in reflected light, white and opaque in transmitted light; one oil droplet, sometimes several smaller ones around the main one [15] (possibly artifacts of handling, JWT), .18–.31 mm diameter; perivitelline space about 6% egg radius.[15]

EGG DEVELOPMENT

Oil globule at the vegetal pole during early development, opposite the blastodisc. Notochord and anlagen of eyes discernible at blastopore closure; embryo extending about half the circumference of the yolk mass; neither pigment nor myomeres apparent. Embryo partly out of its axial plane at blastopore closure (about 54 hours). Myomeres evident but difficult to count after blastopore closure, 14–17, most evident at mid-embryo.[15]

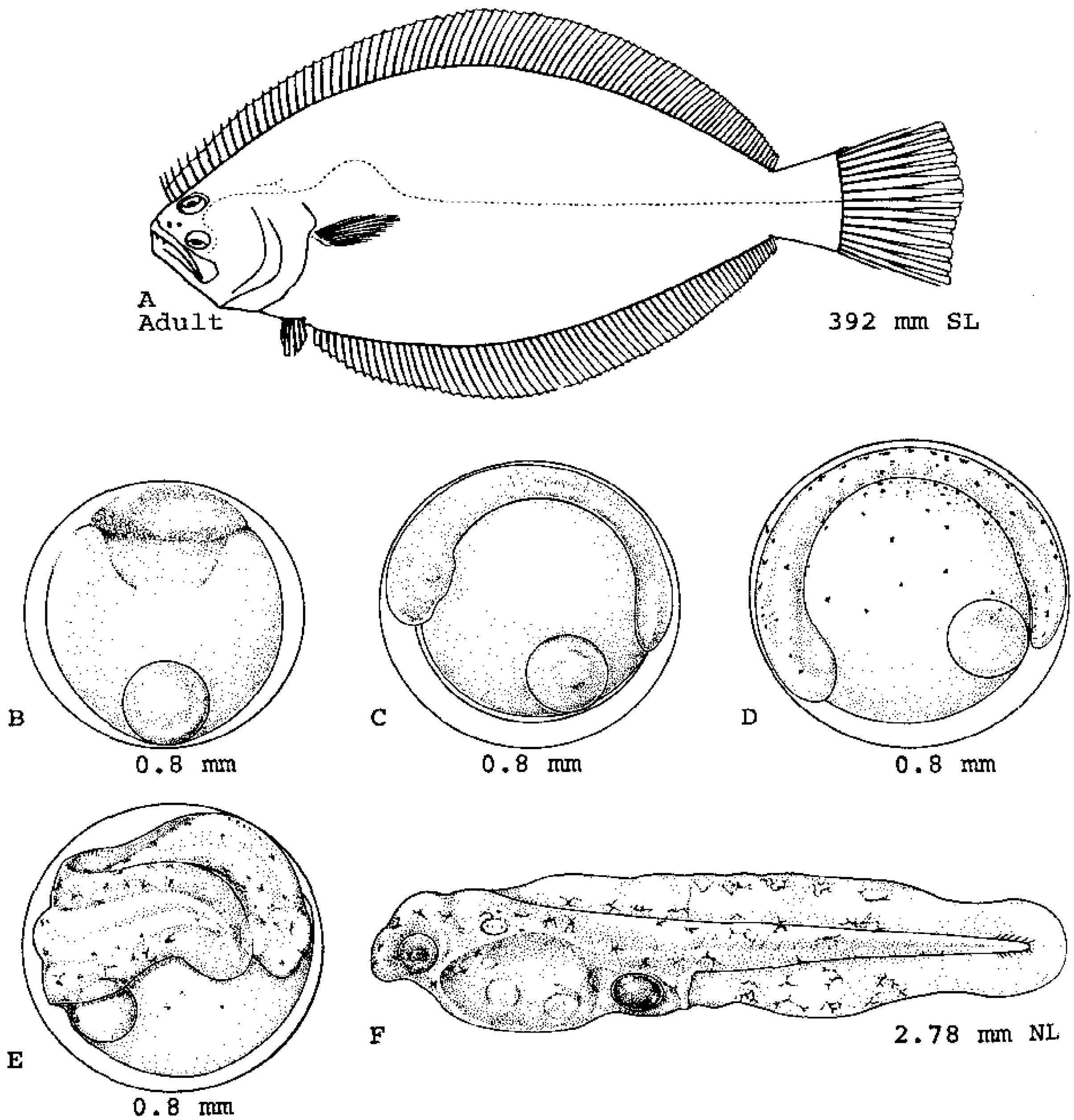

Fig. 79. *Paralichthys dentatus,* Summer flounder. A. Adult, 392 mm SL. B. Egg, 0.8 mm, ventral aspect uppermost, less than 32 hours after fertilization. C. Egg, 0.8 mm, ventral aspect uppermost, blastopore closed, somites visible, optic cups developing between 32 and 54 hours after fertilization. D. Egg, 0.8 mm, ventral aspect uppermost, pigment developed, between 32 and 54 hours after fertilization. E. Egg, 0.8 mm, ventral aspect uppermost, near hatching. F. Yolk-sac larva, 2.78 mm NL, 75 hours after fertilization of eggs. (*A, Norman, J. R., 1934: fig. 39. B-F, Smith, W. G., and M. P. Fahay, 1970: figs. 1, 2. B-F, delineated by Elizabeth Ray Peters.*)

Granular melanophores first appear randomly scattered on the trunk of the embryo. Head and posterior trunk usually devoid of pigment, though some may have a few melanophores. Pigment usually lacking on yolk sac but may occur sparsely along embryonic axis and around oil globule. About 20 somites visible at this stage.[15] Pigmentation of trunk and head increases and caudal region becomes pigmented at about the time the tail becomes free from the yolk sac. Tail extends to or overlaps oil globule and posteriorly the embryo curves laterally out of its axial plane. Melanophores apparent on periphery of ventral two-thirds of yolk sac; in some individuals, these melanophores dendritic, in others granular. 27 myomeres visible.[15]

After bending out of the axial plane, the eyes become defined but remained unpigmented. Somites increase from 27 to 39–41 at hatching. Before hatching oil globule located at margin of anal finfold near the developing vent. As development proceeds, melanophores become increasingly dendritic on the trunk and even more so on dorsal and anal finfolds, which continue to widen. Pigment is randomly distributed on the embryo except for the posterior tailbud and caudal finfold, which are clear. Although the head has additional pigment, the melanophores are more granular than those on the trunk and finfold. Pigment on yolk varies between specimens but is less pronounced than that on embryo.[15]

Incubation period 56 hours at 22.9 C,[29] 72–75 hours at 17.5 C (average),[15,23] and 142 hours at 9.1 C; under natural temperature regimes, 74–94 hours. Temperature limits unknown, but development seen at 9.1 to 22.9 C.[29]

YOLK-SAC LARVAE

Hatch at 2.41–2.82 mm notochord length, yolk absorbed at 3.16 mm SL.

Total myomeres 36–41; at hatching, eyes and snout together equal about 14% notochord length, yolk mass 30% NL. At hatching, body long, thin and compressed except at yolk mass, where it is round in cross-section, head flexed ventrally and snout protrudes only slightly; finfold broad, dorsal fin origin over otocyst, margin slightly concave dorsally and ventrally at peduncle and at location of anus; preanal finfold prominent. Notochord straight; gut not formed at hatching; anus not extending to margin of finfold. Mouth a shallow depression at 3.15 mm, well formed by completion of yolk absorption. Eye pigment appears at 3.1 mm NL. Otocyst visible at all stages. Dorsal bulge of midbrain becomes prominent at 3.15 mm NL. A pair of dorsal cranial spines present.[15]

Pigmentation: Dendritic melanophores are present on the anterior half of anal finfold and anterior two-thirds of dorsal finfold. Anterior three-fourths of body pigmented; finfold and body pigmentation end abruptly, leaving posterior quarter of larva immaculate. Cranial pigmentation includes melanophores on snout, overlying midbrain and an area anterior to yolk and ventral to eye. A few melanophores on anterodorsal portion of yolk; oil globule unpigmented.[15]

LARVAE

Yolk absorbed by 3.16 mm SL[15] and metamorphosis completed around 15 mm SL.[11]

Dorsal fin rays: 0–2 at 6.00–6.83 mm NL; 2–10 at 7.00–7.92 mm NL; 5–13 at 8.00–8.83 mm NL; 9–86 at 9.17 mm NL–10.08 mm SL; complete adult count in all above 10.50 mm SL. Anal fin rays: 0–3 at 8.00–8.83 mm SL; 0–64 at 9.17 mm NL–10.08 mm SL; adult complement in all specimens over 10.50 mm SL. Caudal fin rays: 5–4 at 7.00–7.92 mm NL; 13–16 at 8.00–8.83 mm HL; 13–18 at 9.17 mm NL–10.08 mm SL; adult complement by 10.50 mm SL, 9 epaxial, 8 hypaxial and 1 faintly visible epaxial procurrent ray. Pectoral fin buds present during or just after yolk sac absorption, 3.12 mm NL, appearing as ovate flaps. At 3.16 mm NL pectoral fin one half fleshy pedicel and half fin membrane; actinotrichia evident at 4.55 mm NL; no true pectoral fin rays prior to 12.60 mm SL. Pelvic fins represented by low buds on ventral outline immediately posterior to cleithrum at 9.47 mm NL; 6 rays visible at 12.14 mm SL.[15] One study contradicts these sequences in stating that adult fin ray counts are complete by 8 mm SL.[34] At 9.47 mm NL 39 vertebrae, 41 at 9.47 mm SL. Branchiostegals evident at 8.64 NL, 6 present, posteriormost 3 longer and directed posteriorly, anteriormost 3 directed posteroventrally in larger larvae.[15]

Proportions as average percent of NL or SL: Head length 23 NL at 4.12–4.55 mm NL, increasing to 25–27 in specimens larger than 7.00 mm NL; eye 6–8 NL; preanal length 48 NL at 2.41–2.96 mm NL, changing to 30 SL at 12.08–13.08 mm SL; body depth 14 NL at 2.41–2.96 mm NL to 41 SL at 12.08–13.08 SL.[15]

Body slim, serpentine at 3.16 mm NL, rounder at 4.55 mm NL, compressed somewhat at 7.5–8.5 mm NL. Gape to a point ventral to anterior edge of eye; angular prominent; maxilla first visible at 4.55 mm SL; teeth first visible at 9.47 mm NL. Eye migration may begin as early as 9.5 mm SL. In smallest larvae, choroid fissure evident in the dorsal edge of the iris, at 3.16 mm NL both a dorsal and ventral fissure present, thereafter only ventral fissure present. The two otoliths maintain a position slightly ventral to the center of the oval otocyst at all stages. Dorsal bulge of midbrain prominent, forebrain first visible at 3.16 mm NL, hindbrain indicated by thickening posterior to the midbrain at 4.5 mm NL. Dorsal finfold shifts forward to originate over eye rather than otocyst. At 4.55 mm NL preanal finfold a remnant. At 9.5 mm SL remnants of finfold persist dorsally and ventrally on caudal peduncle. Notochord flexes at 9.47

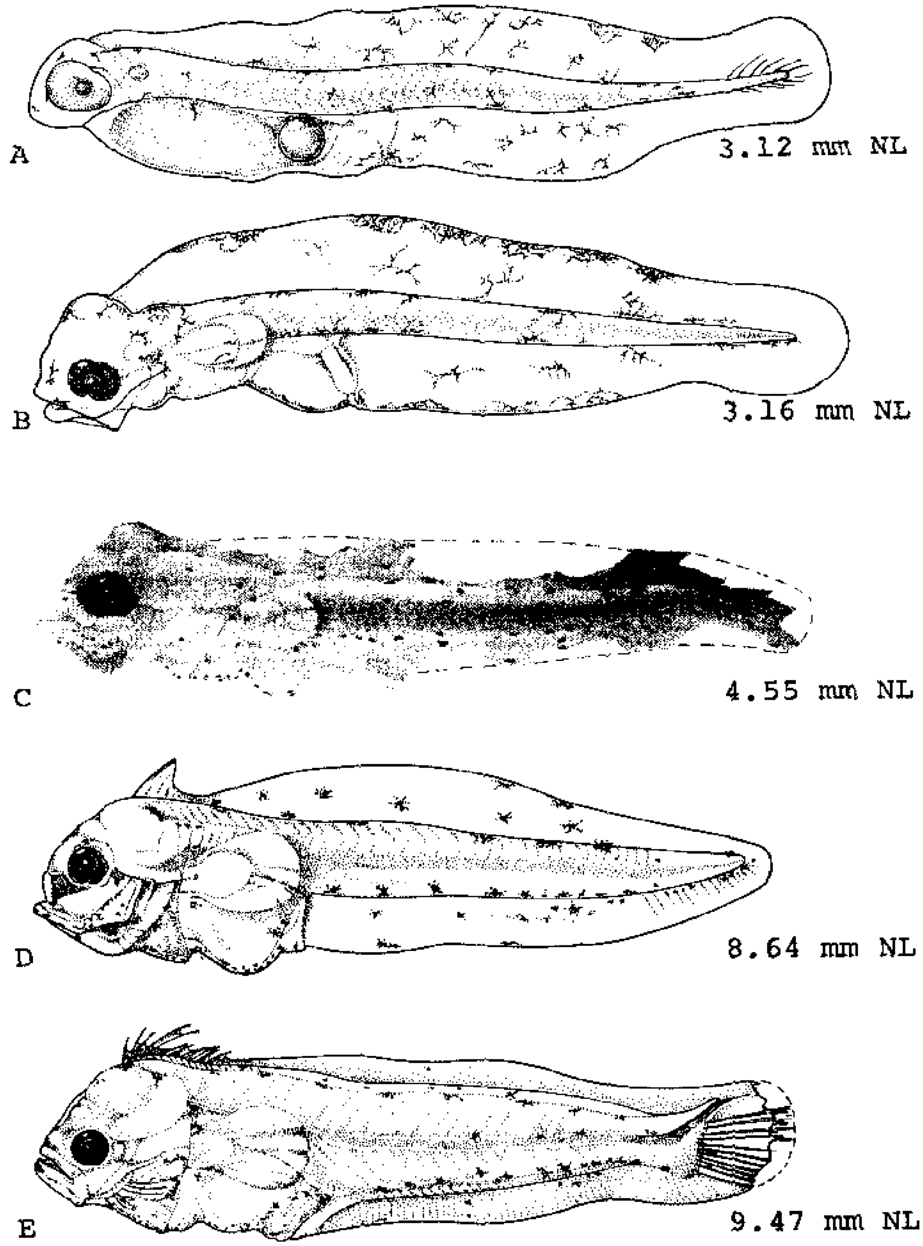

Fig. 80. *Paralichthys dentatus*, Summer flounder. A. Yolk-sac larva, 3.12 mm NL, 12 hours after hatching, yolk reduced. B. Larva, 3.16 mm NL, 96 hours after hatching, pectoral fin present. C. Larva, 4.55 mm NL, *from* plankton. D. Larva, 8.64 mm NL, from plankton, anterior dorsal fin rays differentiated. E. Larva, 9.47 mm NL, from plankton, flexion occurring, caudal and anal fin rays forming. (*A-E, Smith, W. G., and M. P. Fahay, 1970: figs. 3, 5, 6, 7, 8. A-B, D-E, delineated by Elizabeth Ray Peters.*)

mm NL. Anus formed at yolk absorption, located at margin of finfold and directed posteriorly.[15]

Pigmentation: A well defined band of black pigment along the border of anterior four-fifths of dorsal fin and anterior two-thirds of anal fin.[11] At 3.16 mm NL caudal finfold unpigmented except for a few melanophores at its base. The ventral band of pigment well developed but dorsal band not.[15]

At 4.5 mm NL, pigment spots appear on ventral edge of body, gut and throat, also present on lower jaw, preopercle, midbrain, dorsolateral surface of body and finfold. Pattern persists through 8.64 mm NL where, in addition, melanophores are present dorsally along the peritoneum and on posterolateral portion of gut. At 9.47 mm NL–12.60 mm SL similarly pigmented; melanophores retained on ventral edge of gut, throat region, lower jaw, and dorsum of head; ventral row posterior to gut consists of 10–13 distinct spots; along body dorsal edge 6–8 widely separated spots present; usually 3 prominent melanophores posteriorly and a varying number of smaller spots anteriorly on mid-flank. Peritoneal pigmentation dense

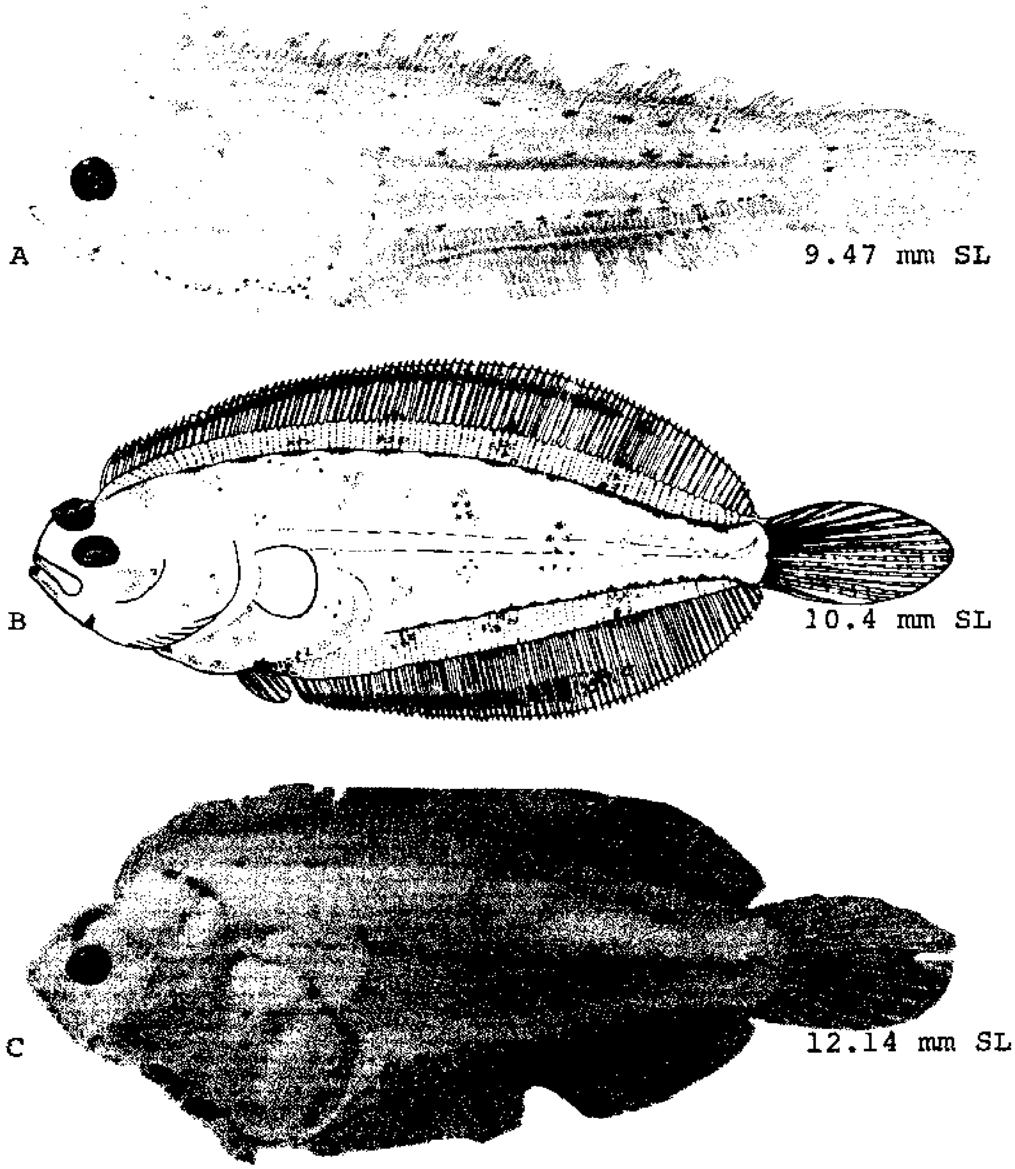

Fig. 81. ***Paralichthys dentatus***, Summer flounder. A. Larva, 9.47 mm SL, fin rays complete. B. Larva, 10.4 mm SL, eye almost in position. C. Larva, 12.14 mm SL, eye not in as advanced stage of metamorphosis as fig. B. Note differences in color pattern. *(A, C, Smith, W. G., and M. P. Fahay, 1970: figs. 9, 10. B, Deubler, E., Jr., 1958: fig. 113.)*

A

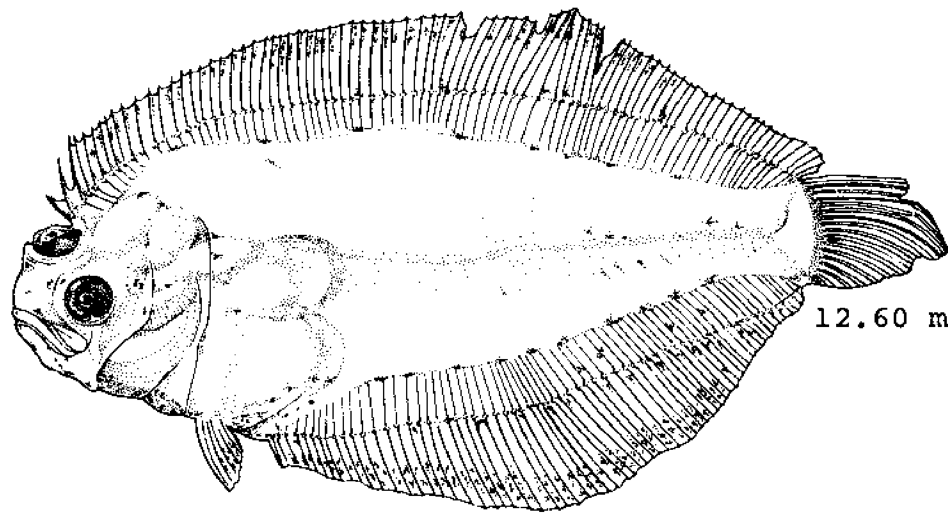

Fig. 82. *Paralichthys dentatus*, Summer flounder. A. Larva, 12.60 mm SL, eye nearly finished in its migration. (*A, Smith, W. G., and M. P. Fahay, 1970: fig. 11. Delineated by Elizabeth Ray Peters.*)

dorsally; pigmentation of posterolateral portion of gut consisting of 3 stellate melanophores. At 12.14 mm SL a large melanophore appears on the side of the head and a single melanophore is present on the mid-flank, immediately posterior to the cleithrum. Pigmentation of median fins is most evident proximally, being more dense on anal fin. At 12.60 mm SL dorsal and anal fins equally pigmented with melanophores situated between rays.[15]

JUVENILES

In a 77 mm TL specimen scales complete.

Pigmentation variable, as in adults, some almost plain brownish with traces of dark spots, others variously speckled and spotted.[14]

GROWTH

23–61 mm in May and June to 76–127 mm in late July to 119–180 mm in December and January.[10,25] At about one year 120–180 mm,[10] 203–254 mm [25] or 114–178; [1] at slightly more than two years 270–280 mm,[10,25] 254 mm.[1] Another, more detailed study gave average lengths as follows: age class I, males 251 mm SL, females 271 mm SL; age class II, males 343 mm SL, females 384 mm SL; age class III, males 401 mm SL, females 477 mm SL; age class IV, males 446 mm SL, females 534 mm SL.[28]

AGE AND SIZE AT MATURITY

Smallest reported with roe, 420 mm TL.[1,14]

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Scophthalmus aquosus (Mitchill), Windowpane

ADULTS

D. 63 [6,7,12,15,16]–71 [2,12,25] (73 [6,16]), first 12–15 free and branched at tips; [6,16] A. 46 [6,7,12,15]–55; [2,12,25] C. 17,[1,16] 9+8; [1] P. (ocular side) 9–12,[16] usually 11; [2,25] V. 6; [25] scales 85 [2]–95 [2,25] (100,[5] 102 [7]); vertebrae 11 [1,2,16]+(22 [16]) 23–25 [1,2,12] (26 [16]); gill rakers 8 [2,5,6]+(18 [16]) 22–26, long,[2] slender.[2,10,16]

Body proportions as percent SL or HL: Body depth 60–70 SL; head 25–30 SL; eye 17–25 HL; upper jaw 45 HL.[2]

Body rhomboid [5,6] or broadly ovate,[6,16] much compressed; [5,6,7,16] snout short; [5,7] mouth large,[6,16] nearly vertical, lower jaw projecting with a bony knob at chin; [7] gape to a vertical through middle of eye or beyond.[2,7,16] Teeth small, uniserial laterally, in a band anteriorly,[7,16] uniserial in both jaws,[6] vomerine teeth similar to jaw teeth.[16] Scales cycloid,[5,15,16,25] small,[5,7] those on blind side smaller,[15] scarcely imbricate.[5,7,16,25] Lateral line with a prominent arch anteriorly.[5,7] Pelvic fin bases extending onto urohyal; [2] dorsal fin origin nearer tip of snout than eye; anal fin origin between tips of pelvic fins; pelvic fins small,[7] broad based, not tapering.[2]

Pigmentation: Ocular side greenish olive,[5,15] reddish,[6,15] grayish [6] or slaty brown, variously mottled with lighter and darker,[15] dotted with small brown spots of irregular shape,[2,5,7,15,16] occasional orange spots; [16] brown spots may be arranged as rosettes.[6] Vertical fins mottled or blotched; [2,5,6,7,15,16] some individuals with irregular patterns of white spotting on body and fin bases; [15] ocular side pectoral fin with crossbands and stippling.[15,16] Blind side whitish but may be irregularly blotched.[15] Whole fish translucent.[5,15]

Maximum length: To 460 mm TL.[6,7]

DISTRIBUTION AND ECOLOGY

Range: Atlantic coast of North America from Gulf of St. Lawrence, Nova Scotia to Florida,[2] north of Cape Cod restricted to isolated locations.[24]

Area distribution: Chesapeake Bight,[6,12,16,17] Delaware River estuary [21] and Chesapeake Bay south of Bloody Point, Maryland.[16]

Habitat and movements: Adults—over sand,[6,11,14,15,16,18] mixtures of sandy silt [16] or mud.[15] In New England no seasonal migrations evident; [15,16] off South Carolina and Georgia, absent from or rare in catches from offshore during summer, fall and early winter, while common inshore all year,[9] found within a Georgia estuary only from January to May.[8] Taken from 5.5 [19]–36.0 ppt salinity, 0–26.8 C,[16] and from shoreline to 73 m,[6,15,23] but most abundant in less than 46 m.[24]

Larvae—surface plankton [16] in 8–16 C and most common over depths of 20–40 m.[24]

Juveniles—sublittoral zone,[22] not going upstream in estuaries. Salinities from 0.45–29.1 ppt; from as shallow as 1.2 m, most common in 6–14 m.[16]

SPAWNING

Season: Temperature dependent, starting in April south of Chesapeake Bay moving northward to New Jersey and New York during summer, not peaking there until fall, at which time breeding recommenced in Virginia and North Carolina.[24] Occasionally split seasons in New York with first season in April–July [20,22] or May–June [21] and second in September [20,21] or September and October.[22] In Virginia spawning stopped at 16–17 C, with spawning most intensive at 8–10 C; in New York started at 7 C and stopped at 20 C, starting again when temperature dropped below 20 C. Eggs found in 18.2–30.0 ppt salinity [22] and from surface [4,16,23] to 10 m [4] or 30 m.[23]

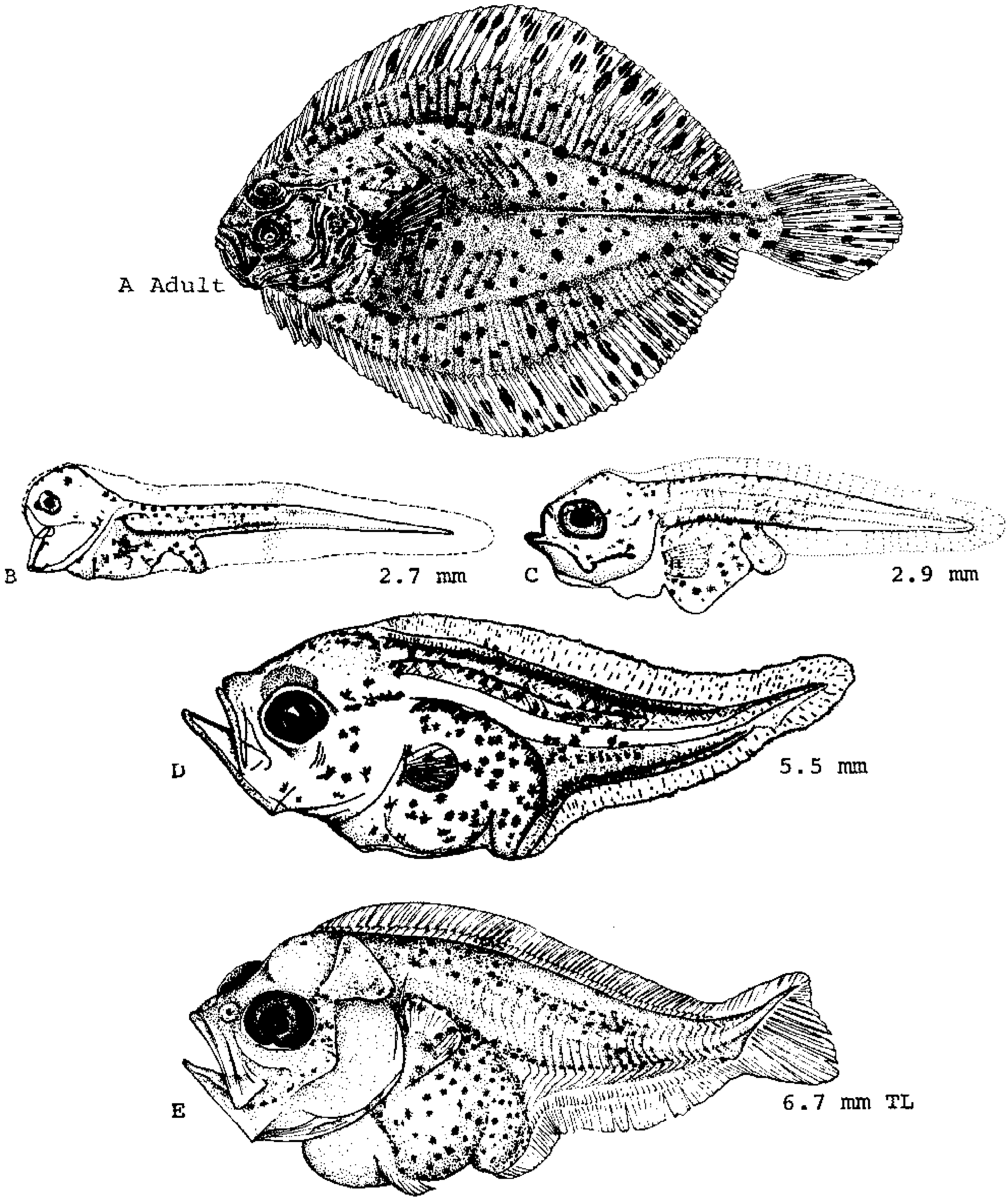
EGGS

Pelagic, spherical; [7,15,16,23] transparent [7,16,23] with surface faintly marked with irregular lines; [16] (.90 mm [23]; 1.00 [6,7,20]–1.38 mm [22] or 2.00 mm; [15] nonadhesive; [23] oil droplets usually 1; [20,22] oil droplet diameter .15–.30 mm when only 1, when 2 or 3, .05–.16 mm; [22] oil droplet colorless,[15,23] pale yellow,[15,16,23] amber, dark or occasionally with melanophores.[15]

EGG DEVELOPMENT

In some putative embryos, embryonic pigment present as early as 14-somite stage. Black spots abundant along dorsal side from snout to tip of tail, less abundant on sides, least abundant on ventral side. In well developed embryos a short horizontal streak vaguely discernible along both finfolds halfway between tail tip and vent. In

Fig. 83. *Scophthalmus aquosus*, Windowpane. A. Adult, length unstated. B. Larva, 2.7 mm. C. Larva, 2.9 mm, distance between anal opening and gut mass proportionally reduced, fin rays forming. D. Larva, 5.5 mm, anus more forward directed, flexion appears to be beginning, eye migration starting. E. Larva, 6.7 mm TL; pelvic fins present, right eye approaching a mid-dorsal position, flexion occurring. *(A, Moore, E., 1947: Frontispiece, redrawn by Tamiko Karr. B, C, Perlmutter, A., 1939: fig. 5. D, Bigelow, H. B., and W. C. Schroeder, 1953: fig. 152. E, original drawing by A. J. Lippson.)*


A Adult
B
2.7 mm
C
2.9 mm
D
5.5 mm
E
6.7 mm TL

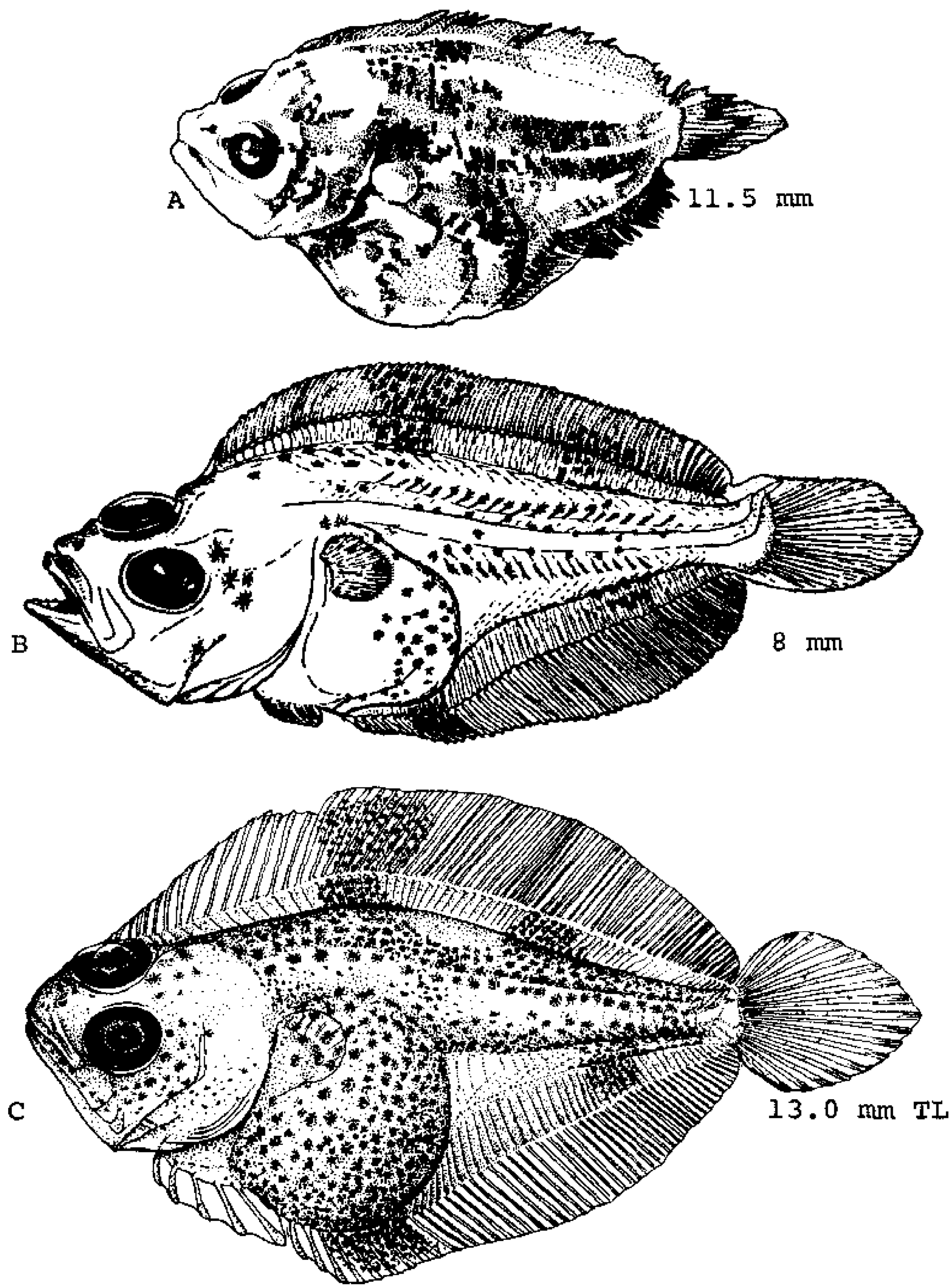


Fig. 84. *Scophthalmus aquosus*, Windowpane. A. Larva, 11.5 mm, right eye approaching mid-dorsal position but no pelvic fin visible. B. Larva, 8 mm, eye on mid-dorsal ridge, pelvic fin visible, color pattern distinctive at this point. C. Larva, 13.0 mm TL, eye nearly adult position, pigment pattern further developed. (*A, Moore, E., 1947: fig. 3. B, Bigelow, H. B., and W. C. Schroeder, 1953: fig. 153. C, original drawing by A. J. Lippson.*)

some, the late embryos faintly streaked on dorsal side of head and nape.[22]

Incubation period 8 days at 10.6–13.3 C[6,7] or 11.7 C.[28]

YOLK-SAC LARVAE

2 mm at hatching[26] *to 5.5 mm at yolk absorption.*

At 5.5 mm finfold represented only by rudiments; notochord flexed;[16] anus opening at finfold margin.[28]

Pigmentation: Heavy pigmentation from behind head to about mid-length; posteriorly free of pigment.[26]

LARVAE

5.5 mm[16] to 13 mm.[26]

At 11.5 mm, 66 dorsal rays, 53 anal rays, 17 caudal rays and 9 pectoral rays but no scales present.[16] Body deep. Eye migration begins at 6.5 mm TL[26] with eye going over head.[14] Otolith present by or before 11.5 mm,[18] fin formation complete at 8.5 mm TL, left pelvic fin as wide at base as at tip, looking like a detached segment of anal fin.[26]

Pigmentation: Approaches complete coverage of both sides of body except caudal end; 3 more or less diffuse

A

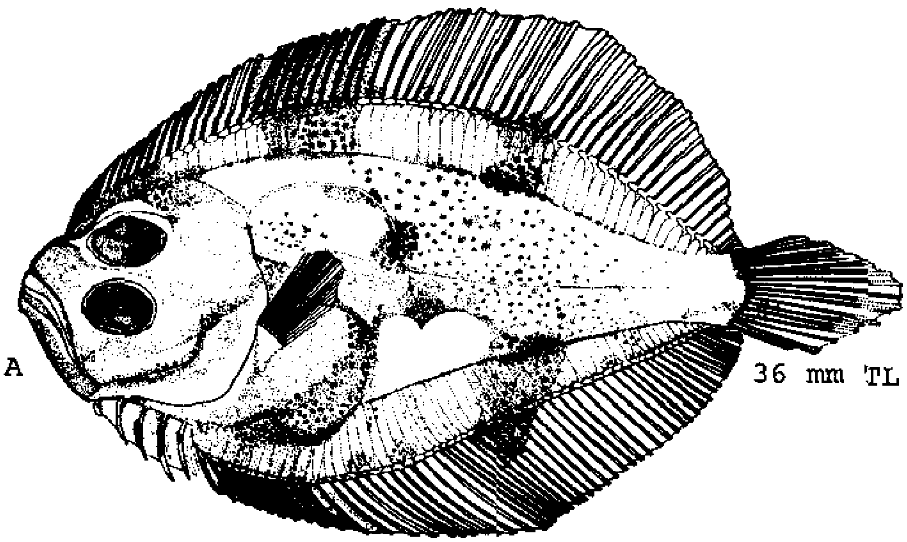


Fig. 85. *Scophthalmus aquosus*, Windowpane. A. Juvenile, 36 mm TL, late larval color pattern breaking up. B. Juvenile, 45 mm TL, adult color pattern assumed. (*A, Original drawing by Nancy Schenk Smith. B, Moore, E., 1947: fig. 3, delineated by Joan Ellis.*)

crossbars of denser pigment present;[16] melanophores large and contrast between pigmented and non-pigmented areas pronounced.[26]

JUVENILES

13 mm [26] to 230–250 mm.[16]

Larval pattern of 3 crossbars persists as traces to 45–60 mm; at 31 mm 4 crossbars, one at rear of head, one at end of intestinal mass on forepart of body; third and fourth past middle of body.[16]

GROWTH

In 11 days 10–22 mm TL;[13] between hatching and February and March, 75–90 mm average length; 1 year, about 60 mm;[16] 2 years, 114 mm[6] or 120 mm; 3 years, 190–200 mm;[16] 4 years, 240[6,16]–250 mm; 5 years, about 280 mm; 6 years, 290–300 mm;[16] 7 years, 305 mm[6] or about 310 mm.[16]

AGE AND SIZE AT MATURITY

3–4 years; 230–250 mm.[16]

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Syacium papillosum (Linnaeus), Dusky flounder

ADULTS

D. 79[6]–94;[10] A. 60[1] or 63[6]–75;[10] C. 17;[5] P. ocular side 11[3,7,8] or 12;[10] V. 6;[5] scales 47[10]–60;[6] vertebrae 10–11[8]+25–26,[5] total 35–36;[5,8] gill rakers 2[1]+7[3] or 8[3,8] or 9, short and stout.[10]

Body proportions as percent SL or HL: Depth 40–47 SL;[6] head 26.0[3]–36 SL; eye 19–29[10] HL or 5.9–6.4 SL.[3]

Body ovate or elongate, compressed;[8] upper profile with a notch in front of eyes;[7,8] mouth large;[1] gape to middle of eye.[1,8] *Teeth conical, curved, biserial in upper jaw* with outer row stronger and enlarged anteriorly, uniserial in lower jaw, vomer toothless.[8] Scales ctenoid on ocular side, cycloid on blind side, small supplementary scales generally present, particularly in the region of the lateral line; *lateral line equally developed on both sides with a* slight curve over the pectoral fins and no supratemporal branch.[8] *Dorsal fin origin in advance of lower eye, anal* fin origin slightly in advance of pectoral fin base; caudal fin bitruncate; pectoral fin on eyed side with upper rays greatly elongated in males.[1]

Pigmentation: Ground color brown[1] or tan with numerous ocelli on entire left side, each ocellus with a dark brown margin, cream-white inner margin and tan center.[5] Males with turquoise marking on maxilla and mandible, extending posteriad along dorsal outline to about 25th ray and along ventral outline to first pelvic fin ray, a pair of parallel lines extending from snout to anterior margin of upper orbit, blind side of dorsal fin tinged with green;[2] males sometimes pigmented on both sides. Both sexes with two areas of pigmentation on the opercular *margin, one area anteroventral to the left pectoral fin*

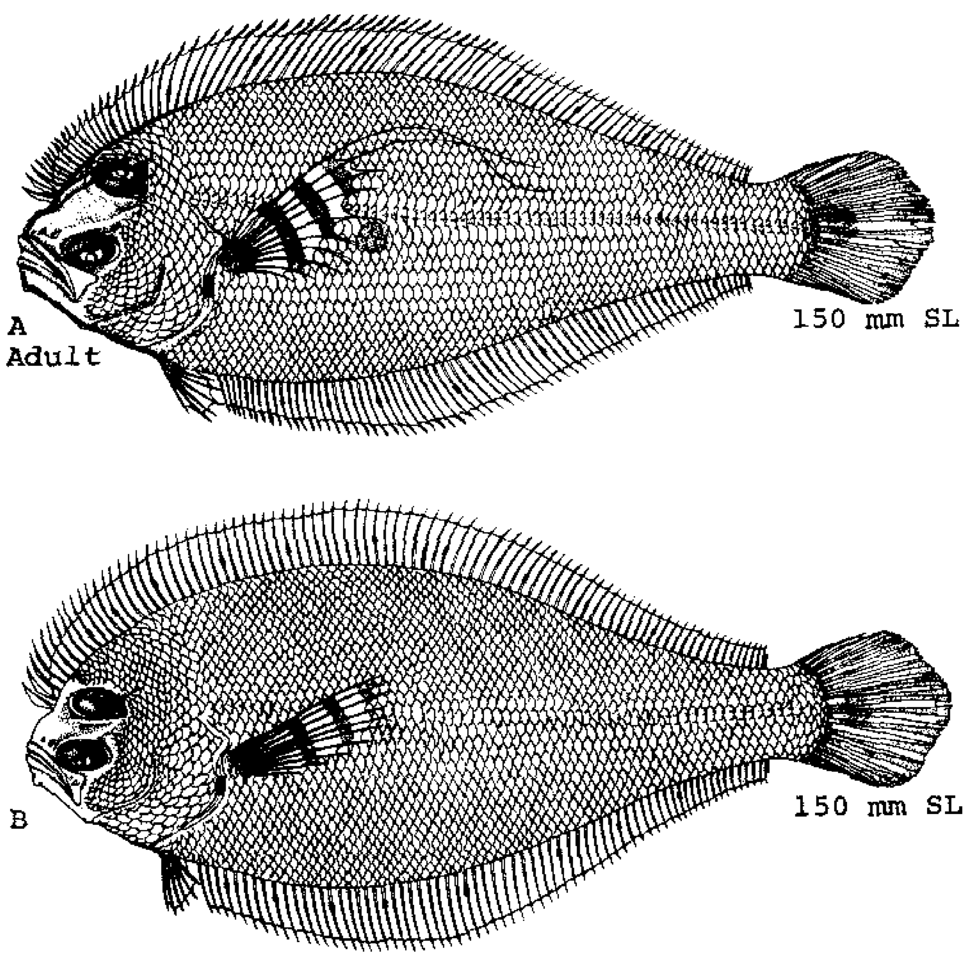

Fig. 86. *Syacium papillosum*, Dusky flounder. A. Adult male, 150 mm SL. B. Adult female, 150 mm SL. Note differences in pectoral fin and interorbital width. *(A-B, Futch, C. R., and F. H. Hoff, Jr., 1971: figs. 16, 17.)*

base, second, often obscure, on the upper opercular margin.[5] An obvious dark spot at the base of the pectoral fin and another, more diffuse, at the tip of the caudal peduncle. Dorsal and anal fins with dark spots, caudal fin with small dark brown spots.[3]

Maximum length: To a little more than 300 mm SL.[1,8]

DISTRIBUTION AND ECOLOGY

Range: North Carolina southward through the Gulf of Mexico and Caribbean, along Atlantic coast of South America to Rio de Janeiro and in the Bahamas and Bermuda,[2] also Ascension Island.[3]

Area distribution: Larvae, but not adults, taken off Virginia, up to extreme northern Virginia, shoreward of the Gulf Stream.[4] Maps in the same paper indicate larvae from off Maryland, but text fails to support this placement (FDM).

Habitat and movements: Adults:—rocky areas,[3] prefer bottoms of calcareous material; marine salinities; 13.9–31.0 C. Reported from 4.6 m [9] to 384 m but records below 92 m are rare [2,4] with records deeper than 182 m possibly being based on misidentifications.[6] Most frequent at stations between 23 and 32 m.[9]

Larvae—pelagic.[4,5]

Juveniles—no information.

SPAWNING

Location: Depths greater than 18 m.[2,5]

Season: Off Florida, from February [2] or April to November [2,5] with a peak in June; [9] off North Carolina, April to October or November.[4]

Fecundity: Females 150–185 mm SL with 22,000–68,000 eggs, and a mean of 55,200.[2]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

2.3 mm SL to 15 or 22 mm SL.

Neural and haemal elements appear between 3 and 4 mm SL, ossification proceeds caudad from the second vertebra, atlas last to ossify, full vertebral complement by 5–6 mm SL; 4 branchiostegal rays at 3.0 mm SL; adult complement of 7 by 5.0 mm SL.[5]

Body proportions as mean percent SL: Head 26.5 at 2.0–2.9 mm SL to 33.7 at 8.0–8.9 mm SL; postanal length 47.8 at 2.0–2.9 mm SL to 45.3 at 8.0–8.9 mm SL; body depth 24.5 at 2.0–2.9 mm SL to 43.0 at 8.0–8.9 mm SL.[5]

Head bluntly rounded in profile at 2.3 mm SL, less rounded with growth, at 4–6 mm SL anterior projections of both frontals producing a small bulge in the anterior profile, anterior profile sigmoid at metamorphosis. Posteriorly directed spines from dorsolateral aspect of frontal in early larvae, prominent in larvae up to 8 mm SL but atrophy in late metamorphosis, disappearing at 22 mm SL. Small teeth develop in larvae at about 3 mm SL, 4 in upper jaw and 6 in lower, increasing to 18 in upper and 20 in lower by 10–12 mm SL; at 13 mm SL larval teeth are replaced by multiserial adult teeth emerging from inner surfaces and margins of lower and upper jaws; eye migration at 15–22 mm SL, eye migrates through a notch in the anterior profile (a groove in the orbital and olfactory bones); nasal capsules appear at 3 mm SL and tubular nostrils are evident by 10–13 mm SL. Conspicuous preopercular spination in early larvae, at 3.0 mm SL 2 large spines develop from the preopercular angle, lower one atrophies while the other becomes sharply hooked with side spinules; upper preopercular limb with 2–3 small projections, lower limb with 2–4.[5]

Dorsal fin with 5–8 elongate anterior rays at 3.3 mm SL, these increasing in length until 7–8 mm SL then atrophy to same length as other rays; other rays begin to appear at 5 mm SL, progressing caudad; full complement at 10–13 mm SL; fin ray ossification precedes that of pterygiophores; anal fin formation begins at about 5 mm SL, complete by 10–13 mm; proliferation proceeds caudad from the anterior; rays ossify before pterygiophores; caudal fin with 7–8 rays ossified before 5–6 mm SL, full complement of 17 by 6–7 mm SL; pectoral fins small fleshy based at 2–3 mm SL, persisting through 10–12 mm SL, when ray ossification begins, ossification of left fin precedes that of right, typical adult count by 15–20 mm SL; pelvic fins begin as small buds from ventral body margin immediately posterior to the cleithral symphasis, left developing first, at 6 mm SL left pelvic fin with 4 rays, right still a bud, at 7 mm SL both fins complete but left much longer than right becoming equal in length at 15–22 mm SL. Notochord flexure at 5–6 mm SL; gas bladder persists at 15 mm SL.[5]

Pigmentation: Eyes pigmented at 2.3 mm SL; first nonocular pigment a series of 2 or 3 melanophores developing at the retroarticular bone. At 3 mm SL several melanophores dorsal to each frontal spine, one on the

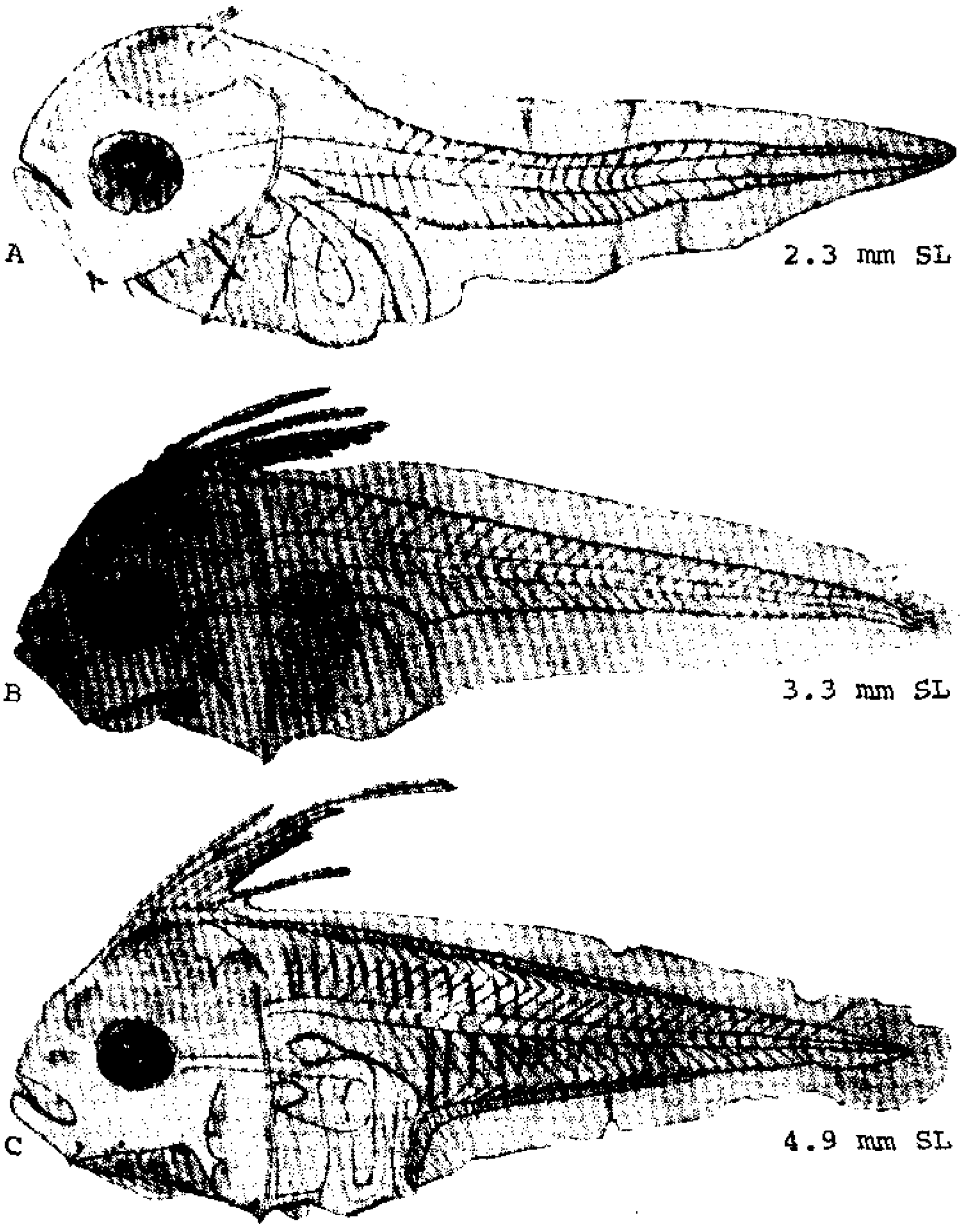

Fig. 87. *Syacium papillosum*, Dusky flounder. A. Larva, 2.3 mm SL. Frontal spines well developed, preopercular spines very long and spike-like. B. Larva, 3.3 mm SL. Elongated dorsal tentacles present, frontal spines still present, preopercular spines still spike-like, swim bladder present, branchiostegal rays and caudal fin rays forming. C. Larva, 4.9 mm SL. Dorsal tentacles pigmented at tip, spine at angle of preopercle becoming broad, blade-like with a secondary point, anal fin rays forming, pelvic fin bud present. (*A-C, Futch, C. R., and F. H. Hoff, Jr., 1971: figs. 2, 3, 4.*)

brain at each otic capsule, several anterior to the cleithral symphasis and many small ones along the isthmus and gill membrane margins. At about 5 mm SL, 2, rarely 3, stellate melanophores on each hypobranchial membrane and several round ones ventral to the hypohyal bones, the latter chromatophores are clearly larger and more abundant on the left side; all other chromatophores more or less symmetrical in distribution and abundance. Chromatophores of frontals, precleithral bone and left hypohyal become fewer but increase in size through early metamorphosis; those of gill membrane margins and isthmus disappear; hypobranchial pigmentation is unaltered; hypohyal, hypobranchial, retroarticular and precleithral pigmentation disappears between 15 and 22 mm SL.[5]

Elongate anterior dorsal fin ray tips heavily pigmented,

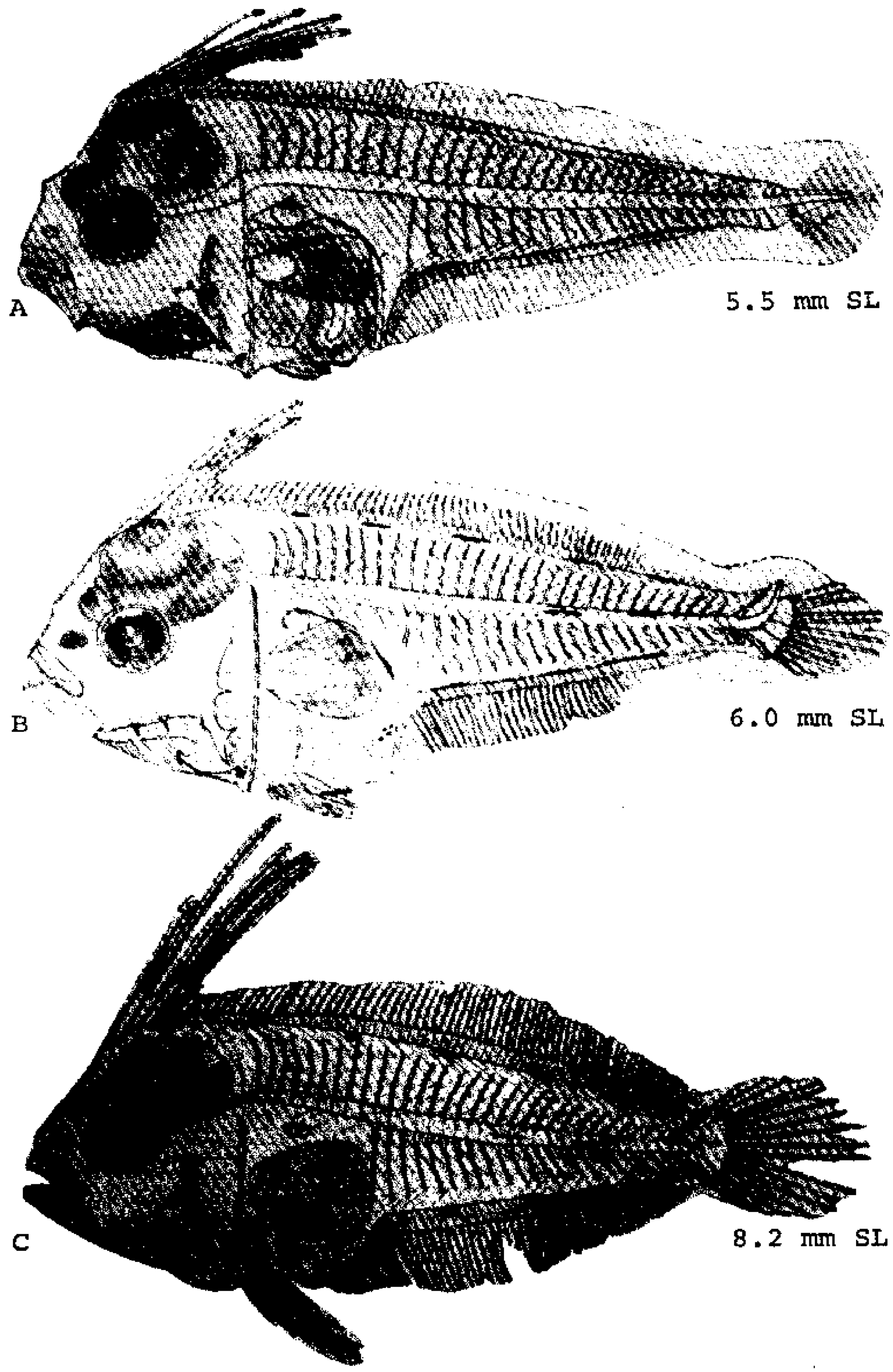

Fig. 88. *Syacium papillosum*, Dusky flounder. A. Larva, 5.5 mm SL, dorsal and anal fin rays forming, pelvic fin rays well developed, dorsal and ventral pigment spots elongating. B. Larva, 6.0 mm SL, flexion of notochord, frontal spine reduced in proportion. C. Larva, 8.2 mm SL. Frontal spine almost completely degenerated, preopercular spine reduced in proportion, swim bladder much reduced. (*A-C, Futch, C. R., and F. H. Hoff, Jr., 1971: figs. 5, 6, 7.*)

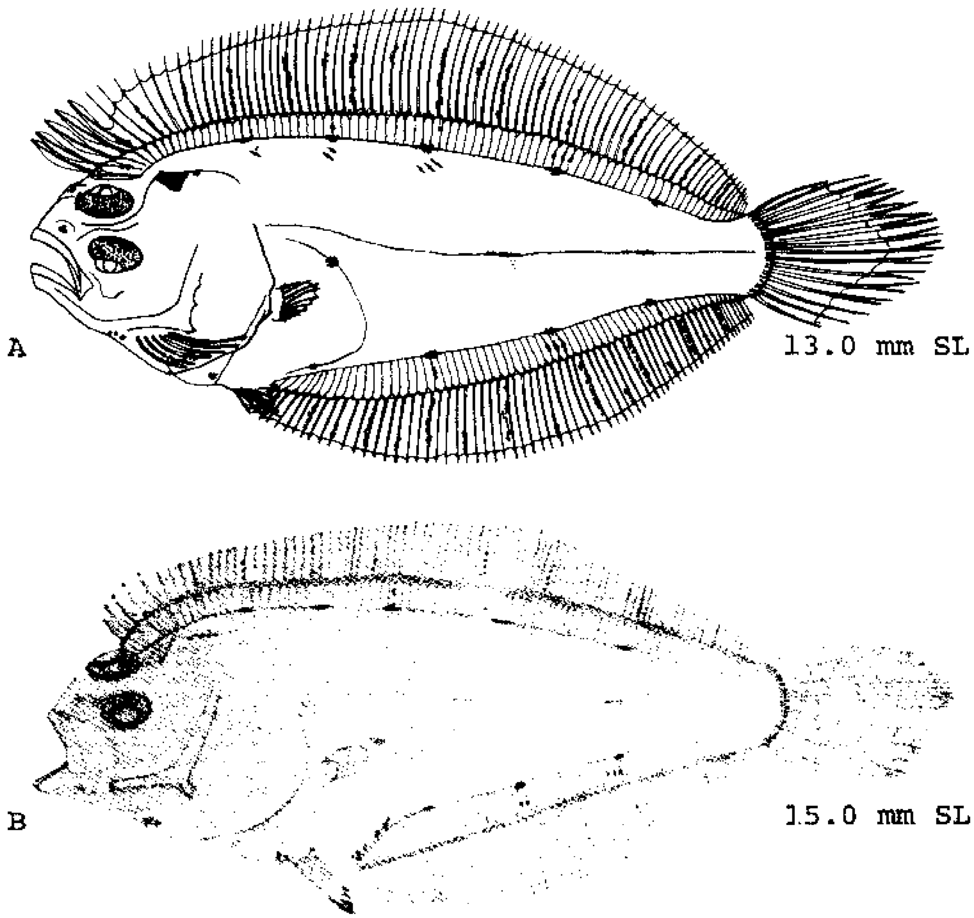

Fig. 89. *Syacium papillosum*, Dusky flounder. A. Juvenile, 13.0 mm SL. Eye migration complete. B. Juvenile, 15.0 mm SL. Eye migration may be complete, some variation in size at which eye migration is completed. (*A-B, Futch, C. R., and F. H. Hoff, Jr., 1971: figs. 8, 9.*)

this pigment retained until the tips atrophy. At 13–15 mm SL small chromatophores develop on individual rays in an evenly spaced series along each fin, about 12 on dorsal fin, 9 on anal fin. A small chromatophore developing on the base of each caudal fin ray at about 13 mm SL, disappearing by 22 mm SL. Left pelvic fin tip highly pigmented in specimens up to 15 mm SL.[5]

Small chromatophores located along ventral gut margin in early larvae, concentrate at anus at about 8 mm SL, this pigment obscured as the anus moves forward. At about 4.5–5.0 mm SL several stellate melanophores appear on the gut dorsal to the anus, those of the right side soon dissipate, but those of the left side proliferate and congregate to form a large spot at the anal fin insertion. Moderate to heavy pigmentation covering the swimbladder and uppermost peritoneum appearing at 3 mm SL and remaining visible through about 15 mm SL.[5]

In early larvae one or two melanophores develop on most myomeres at dorsal and ventral body margins adjacent to larval finfold; at about 5 mm SL these seem to merge to form large spots on dorsal and ventral body margins; these spots develop caudad and by about 8 mm SL 5 dorsal spots and 3 ventral spots present, each spot associated with 2–6, typically 3–4, pterygiophores; on left side spots separate, on right side small melanophores form a thin line connecting these spots; in some individuals, melanophores develop on pterygiophores distal to the marginal spots; with growth, marginal spots condense and are associated with one, occasionally two, pterygiophores; regularly placed. Location of spots in relation to pterygiophores as follows: dorsal series; origin of dorsal to first spot 16–18; first to second, 8–9; second to third, 10–12; third to fourth, 15–17; fourth to fifth, 16–18. Anal series: anal origin to first spot, 13–17; first to second, 14–17; second to third 16–18.[5]

Pigmentation develops along left side body midline at about 5 mm SL, formed by about 3 small chromatophores at the level of caudal vertebrae 18–22. At about 6 mm SL a longer line of chromatophores develops on the right side body midline. At about 7 mm SL, a second set of midline pigmentation develops on the left side approximately at the level of caudal vertebrae 10–13. From 5 to 15 mm SL melanophores present on dorsal surface of nerve cord.[5]

JUVENILES

15–22 mm to about 100 mm SL.

Small, irregularly placed spots on vertical fins of juveniles and adults, often a spot on the mid-caudal region. Above 50 mm SL, 4 transverse pigment bands spaced across left pectoral fin, distance between proximal and next band larger than remaining interband distances; distal band sometimes indistinct. Entire pelvic fin heavily pigmented. Large spot at anal fin insertion persisting until 50–60 mm SL.[5]

GROWTH

No information.

AGE AND SIZE AT MATURITY

100–130 mm SL; females may mature at as little as 82.2 mm;[2] males show secondary sexual characteristics (elongations of first two dorsal rays) at 110–130 mm SL.[5]

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Glyptocephalus cynoglossus
Hippoglossus hippoglossus
Limanda ferruginea
Pseudopleuronectes americanus

righteye flounders
Pleuronectidae

FAMILY PLEURONECTIDAE

For methods of distinguishing this flatfish family from the others see the discussion of family Bothidae. This family is primarily cool temperate and subarctic in distribution, reaching its southern limits in this area except for *Pseudopleuronectes americanus*, which reaches as far south as Georgia. *Hippoglossus hippoglossus* and *Glyptocephalus cynoglossus* are the two deepest dwelling forms and are also unlikely to be common in shore zones for most of their life cycle. These two species are also wide ranging, occurring on both sides of the North Atlantic.

Glyptocephalus cynoglossus (Linnaeus), Witch flounder

ADULTS

D. (95) 97 [10]–117 [24] (120); [10] A. 87 [3,5]–101; [24] C. 20–24, 12–16 unbranched or 0–1 + 11 + 11 + 0; [24] P. ocular side, 9–13, 6–10 unbranched; [10] V. 6; [10,23] scales, blind side 109–150,[6] ocular side 110–140; [6,10] vertebrae 57 [24]–58,[6,14,24] 11–12 + 45–47 [24] or 12–14 + 45–46; gill rakers short, stout, 6–9 on lower limb; [10] teeth $\frac{8\text{–}15 + 17\text{–}26}{9\text{–}16 + 20\text{–}26}$; [10] 2 + 4 or 5 long plyloric caeca.[10]

Body proportions as percent SL or HL: Depth of body 28.6–41.7 SL; head length 15.4–22.2 SL; lower jaw about 33 HL; [10] eye 25 [3,23]–33 HL.[14]

Body elongate, oblong, much compressed; head small; mouth small; gape not reaching front of eye [3] or just reaching front of eye.[10] A single series of incisor-like teeth in each jaw.[3,5] Lateral line straight or with an arch, individual variation.[6] Dorsal fin origin over anterior part of upper eye [10] or over middle of eye; [3] caudal fin rounded; [3,10] anal fin preceded by a short, sharp, forward pointed spine,[5] its origin under base of pectoral fin; pelvic fins inserted slightly in advance of pectoral fin base on mid-ventral ridge.[3]

Pigmentation: Body brownish or grayish brown, body and fins speckled with minute black dots which are generally fewer, larger and more scattered on blind side,[10] sometimes with darker transverse bars; [3] dorsal and anal fins more or less dusky toward margins,[10] sometimes spotted and tinged with violet; [3] anterior rays sometimes tipped with lighter color; [10] pectoral fin membrane on eyed side dusky to black, on blind side grayish-white with minute dark points throughout.[3]

Maximum length: To 781 mm TL,[23] western North Atlantic specimens reaching larger sizes than those in eastern North Atlantic.[18]

DISTRIBUTION AND ECOLOGY

Range: Both sides of the Atlantic,[1,5] in eastern Atlantic from Murmansk to France including western portion of Baltic Sea,[11] in western Atlantic from Newfoundland to North Carolina; [12,18] reaches north coast of Iceland only in years with above average temperatures.[21]

Area distribution: Throughout the Chesapeake Bight,[1,2,9] mostly at depths greater than 90 m.[12]

Habitat and movements: Adults—on mud,[3,5,13] clay,[5,28] mud or clay mixed with sand,[3,5,28] smooth ground between rocky patches,[5] rarely on sand; [28] in Gulf of Maine no evidence of migrations,[5] in the Gulf of St. Lawrence [13] and in Swedish waters may be some onshore movements in spring and offshore in fall,[5,27] seasonal movements may be as little as 6–12 km; [13] reported from 33–35.2 ppt salinity; [28] −0.6 [3,5]–10 C; [3] and 18.3 m [3,5,10]–1569 m,[3,5] most common at 46–274 m off Canada,[3] 90–330 m in the Mid-Atlantic Bight [12] or 200–250 m in Swedish waters.[27]

Larvae—pelagic,[13] over depths of 28–250 m; [20] 5 [12]–18.8 C,[20] most common at 5 C; [12] most common at 29–40 m over depths of more than 146 m [13] but reported from around 165 m over depths of about 320 m.[27]

Juveniles—more likely than adults to exhibit seasonal movement; [27] reported from 34.9–35.7 ppt salinity and 4.1–11.3 C; in Nova Scotia bimodally distributed as to depth being most common at 183 m and 256 m; [13] off Virginia found from 166 m to 1408 m,[15] most common at 900 m.[15,17]

SPAWNING

Location: Occurs in localized areas,[20] near shore out to slope waters, usually at depths toward the shallow side of the normal range,[28] probably at 70 to 260 m [13] with most occurring at 100–160 m.[28]

Season: Spawns in Swedish waters March to July,[27] in the North Sea May to September with peak in July,[11] in the Irish Sea March to May,[19] in western North Atlantic waters peak spawning in May and June, ending in July, earliest in more southerly waters.[12]

Temperature: Occurs from about the freezing point of salt water to 9 or 10 C, mostly in the range of 3.9 to 8.9 C.[5]

EGGS

Pelagic; [5,7,20] spherical; [3,5,20] transparent; [5] diameter of European eggs about 1.25 mm at beginning of spawning season and about 1.13 mm at the end,[4] sizes reported range from 1.07 [5,8] to 1.45 mm [20] with averages of 1.25 mm [7,16] or 1.27 mm; chorion thick, grooved with many folds; yolk diameter 0.95–1.05 mm; [20] perivitelline space narrow.[5,20]

EGG DEVELOPMENT

Embryo with 34 somites, pigmentation weak with condensed melanophores on back of body and head. Other embryos reported with 47 somites, 12 + 35, olfactory capsules visible, alimentary canal a straight tube, rudiments of pectoral fin present on somites 1 and 2, pigment cells scattered, but two rows of melanophores distinct on sides

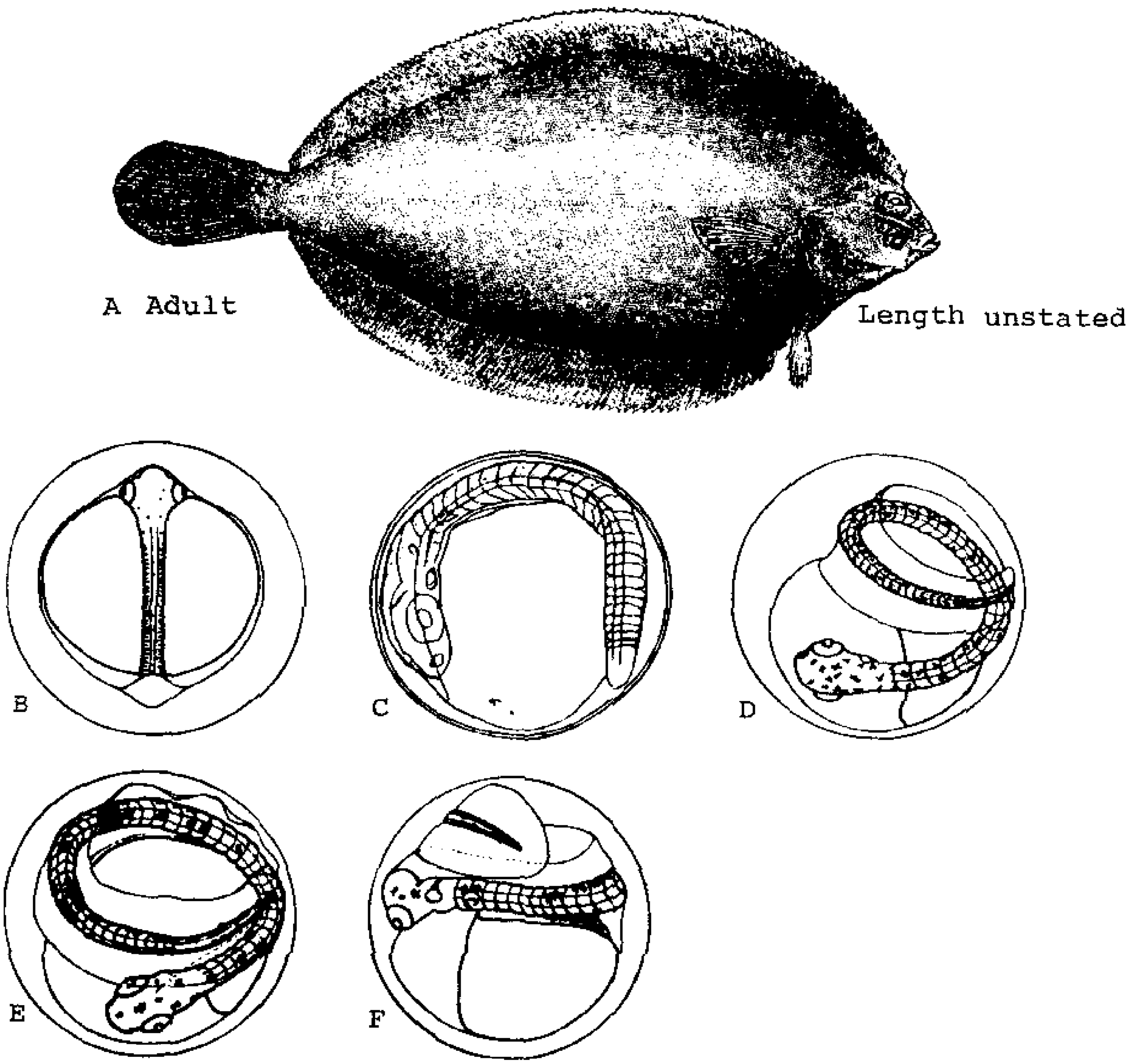

Fig. 90. *Glyptocephalus cynoglossus*, Witch flounder. A. Adult, *length unstated*. B. Egg, *diameter unstated*, early development. C. Egg, diameter 1.16 mm, approximately the same developmental stage as previous figure. D. Egg, diameter unstated, later development. E. Egg, diameter unstated, late development. F. Egg, diameter unstated, just prior to hatching. (*A, Goode, G. B., 1884: pl. 57. B, D-F, Evseenko, S. A., and M. M. Nevinsky, 1975: fig. 1. C, Ehrenbaum, E., 1905: fig. 71.*)

of body, finfold and yolk sack unpigmented, one specimen with a mass of melanophores in the anal area and three belt-like pigment *masses on postanal part of body*.[20] Other reports indicate a lack of pigment prior to hatching.[5,16]

Incubation period 7.8 days at 8–9.3 C or 7 to 8 days at 7.8–9.4 C.[5,5] Normal development in the laboratory occurs over the range 7.2 to 12.8 C.[5]

YOLK-SAC LARVAE

Hatching length variously reported as 3.9 mm,[11,25] 3.52–5.59 mm with a mean of 4.82 mm[7,16] or 4.9 mm,[5] yolk absorbed by 5.9 mm TL.[11]

Preanal length 25.9% SL at 5.8 mm;[20] characteristic body shape with a short abdomen and long postanal region;[25] yolk mass large and homogeneous at hatching, 1.07–1.25

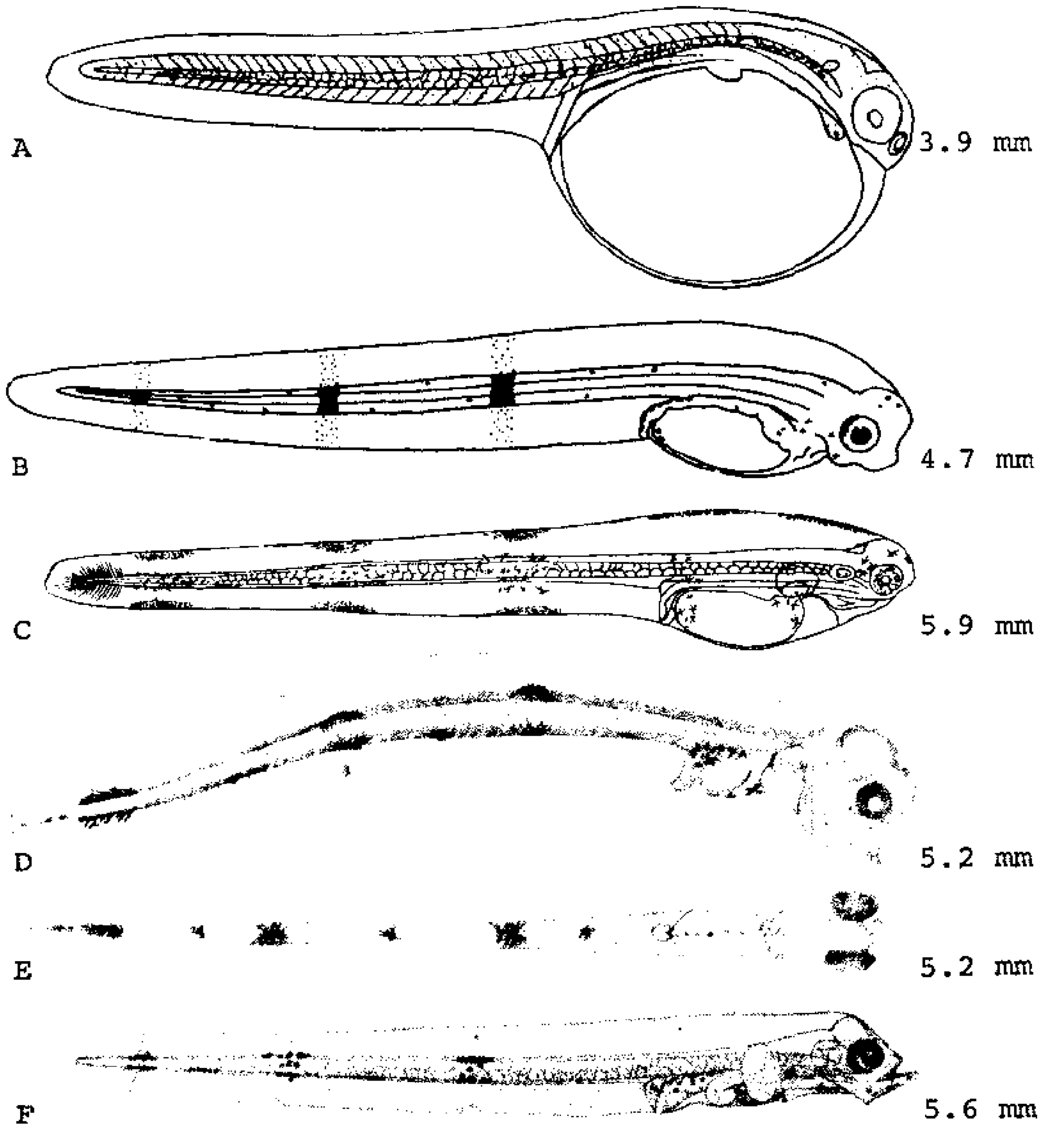

Fig. 91. *Glyptocephalus cynoglossus*, Witch flounder. A. Yolk-sac larva, 3.9 mm, newly hatched. B. Yolk-sac larva, 4.7 mm. C. Yolk-sac larva, 5.9 mm, 1 day after hatching. D. Larva, 5.2 mm. E. Larva, 5.2 mm, ventral view of larva from previous figure. F. Larva, 5.6 mm. (*A, C, and F, Ehrenbaum, E., 1905: fig. 71. B, Miller, D., 1958:51. D, E, Williamson, H. C., 1904; pl. 16, D reversed.*)

mm in cross-sectional diameter at hatching,[11] present only as traces near the cleithrum at 5.8 mm;[20] teeth present at 5.2 mm;[25] brain differentiated into its main parts by 5.8 mm;[20] no traces of fin rays in median fins at 5.2 mm, caudal diphycercal;[18] pectoral fin fan-like at 5.8 mm;[20] finfold wider at 5.9 mm than at hatching;[25] gut with a loop in middle of coelom;[20] anus immediately behind yolk sac,[11,16] opening at edge of finfold.[20]

Pigmentation: At hatching, larvae appear pale chrome yellow in reflected light and dark yellow by transmitted light, this on head, eye, trunk, yolk and caudal region,[3] may have a number of very minute dots scattered on sides,[11,25] the yellow pigment intensifies with growth,[3] becoming greenish in transmitted light;[25] an aggregate of expanded melanophores appears in the region of the anus;[20] another similar aggregate of pigment develops over the center of the yolk sac;[7] in the postanal region 3 vertical bars develop about equally spaced, may have 3 small aggregates of pigment between bars,[25,26] the vertical bars extending onto finfold in fresh material but restricted to body in preserved specimens;[7] at 5.2 mm a

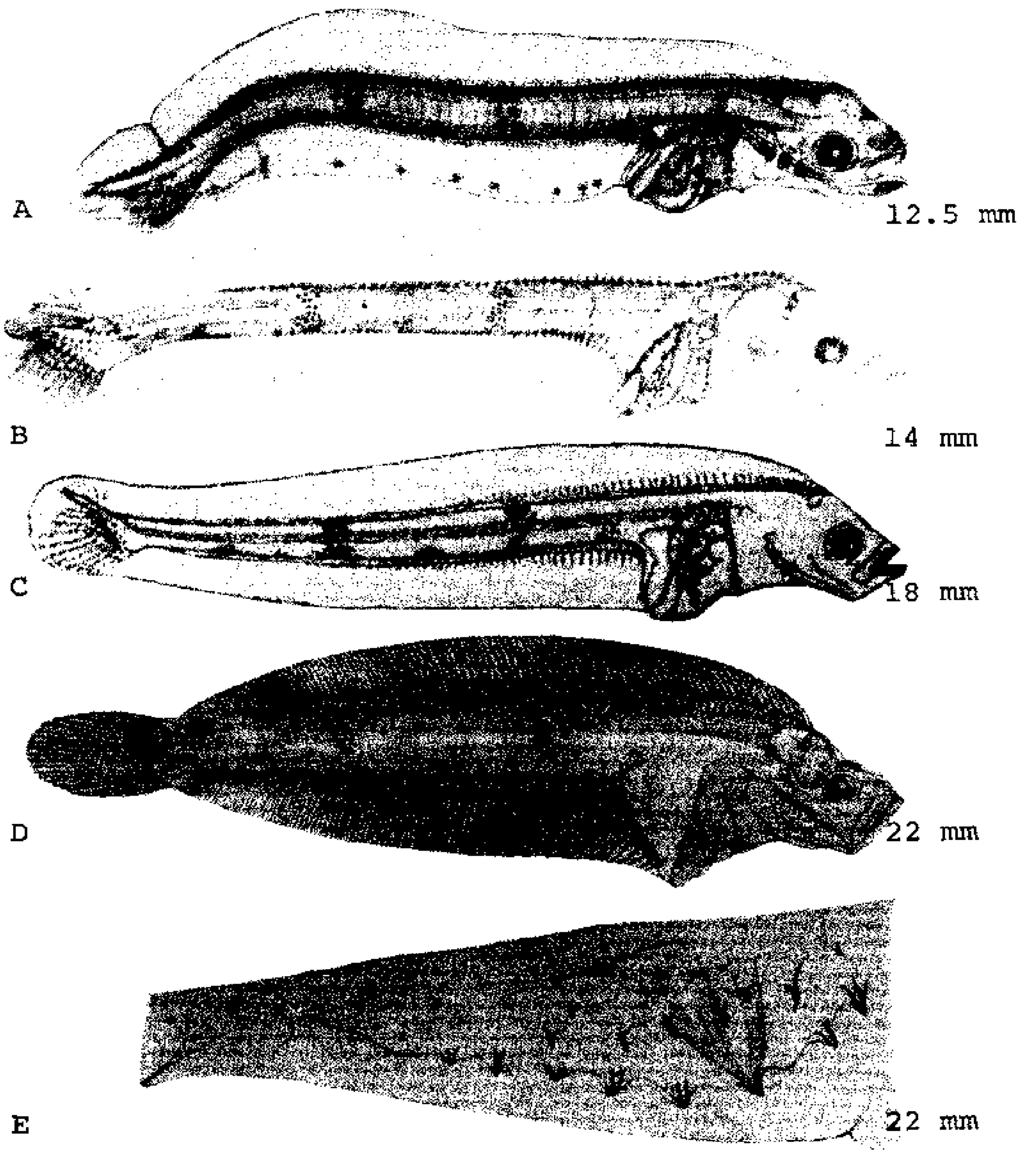

Fig. 92. ***Glyptocephalus cynoglossus*, Witch flounder.** A. Larva, 12.5 mm. B. Larva, 14 mm, note developing ventral concavity behind operculum. C. Larva, 18 mm, notochord flexion in progress. D. Larva, 22 mm, eye beginning migration. E. Preoperculum of larva, 22 mm, showing pattern of spines. (*A, B, Williamson, H. C., 1904: pl. 16. C, Petersen, C. G. J., 1904: pl. 2. D, E, Holt, E. W. L., and L. W. Byrne, 1903: pl 3.*)

few melanophores at point of mandible, and a group of melanophores located ventrally in pectoral region; eye pigmented by 5.2 mm.[25]

LARVAE

Reported as small as 6 mm,[7] metamorphosis completed from 4 to 6 months to possibly a year after hatching when larvae are between 35 mm[7,16] and 50 mm,[5] usually complete by 40–42 mm in Irish Sea and by 48 mm[25] in Skagerak.[26]

At 16.7 mm 85 dorsal and 68 anal pterygiophores,[20] dorsal and anal fin ray counts in adult range in all specimens over 20 mm TL;[7,16] caudal fin rays 18 at 16.7 mm, adult complement by 22.5 mm;[20] pectoral fin quite large but without rays at 6 mm;[11] pelvic fins with 4–5 rudimentary rays at 22.5 mm; myomeres 11–12 + 43–45, total 54–57;[20] vertebrae 12 + 46.[16]

Preanal length 29.3% SL at 16.7 mm, 35.1% SL at 22.5 mm.[20]

Body with a concave ventral profile in throat region at

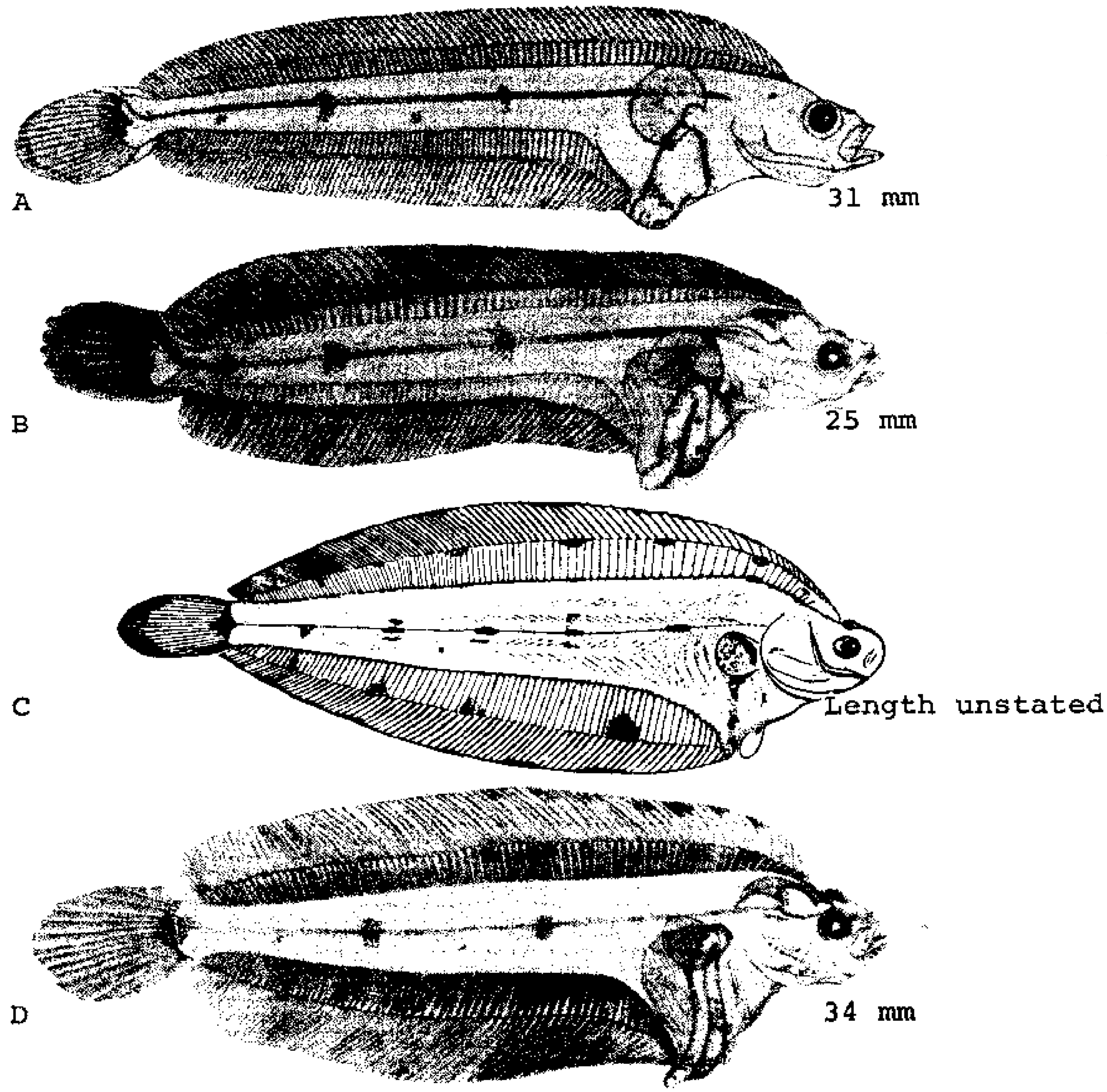

Fig. 93. *Glyptocephalus cynoglossus*, Witch flounder. A. Larva, 31 mm. B. Larva, 25 mm, more advanced development, despite being shorter than previous figure. C. Larva, length unstated. D. Larva, 34 mm. (*A, Petersen, C. G. J., 1904: pl. 2. B, D, Williamson, H. C., 1904: pl. 16. C, Goode, G. B., and T. H. Bean, 1895: fig. 356a.*)

15 mm,[5,7,16] postanal region slender; [25] upper and lower jaw bones formed by 16.7 mm; 3 teeth present in each side of both upper and lower jaws at 22.5 mm; left eye beginning to move at 22.5 mm,[20] visibly moved at 25 mm and on median ridge by 38 mm [25] or 40 mm; [5] preoperculum with prominent spines,[25,29] these first noticed at 12.5 mm,[25] 5 anteriorly directed spines + 3 posteriorly directed spines + 1 in middle of preopercle; at 16.7 mm, 4 anteriorly directed spines + 7 posteriorly directed spines + 8 in middle of preoperculum pointing variously; urinary bladder visible at 16.7 mm; [20] dorsal fin rays first evident at 12 mm TL; [11] anal fin rays evident by 15 mm; [16] caudal fin rays appear at 15 mm; [5] pectoral fin in larval condition at 22.5 mm,[20] well developed at 42 mm in one report [25] but still larval in form at 48 mm in another; preanal finfold lost by 15 mm,[26] otherwise finfold still complete at 16.7 mm; urostyle flexed at 16.7 mm; [20] gut looped in the middle; [11] anus backward directed at 15 mm; [26] heart with 2 chambers, anterior to cleithrum at 16.7 mm; [20] liver lying in front of midgut loop.[11]

Pigmentation: Black and yellow pigment generally scattered, makes 5 transverse bands that extend onto finfold,[3]

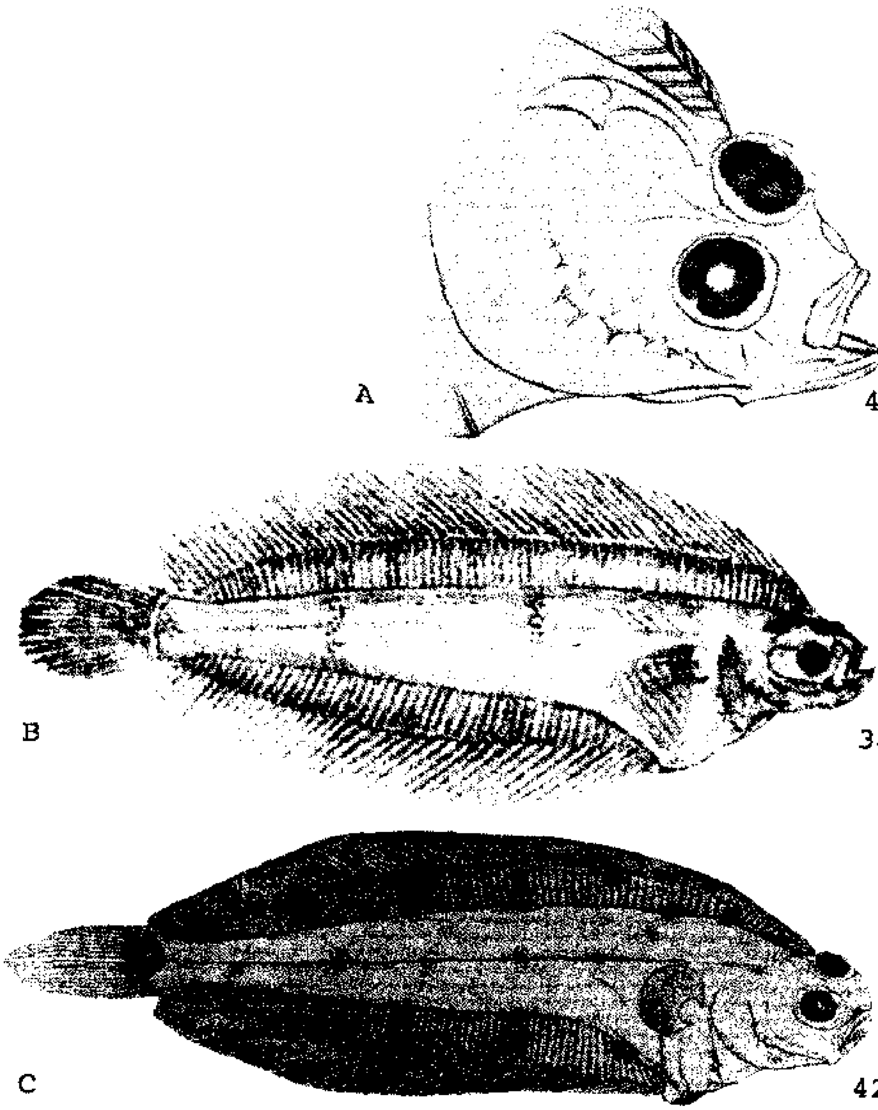

Fig. 94. *Glyptocephalus cynoglossus*, Witch flounder. A. Head of larva, 40 mm, showing preopercular spine development. B. Larva, 38 mm. C. Larva, 42 mm, eye nearing final position. (*A, B, Williamson, H. C., 1904: pl. 16. C, Petersen, C. G. J., 1904: pl. 2.*)

of these evenly spaced on caudal portion, 1 in anal region and 1 on forepart of body,[11] most anterior band may be indistinct;[25] yellow pigment orange in transmitted light, chrome yellow in reflected light; eye jet black[11] or with a bluish luster;[25] pigment cells on intestinal loops, mostly on ventral parts, *and on left side of head above mesencephalon;*[20] pigment present in lower jaw and anterior ventral region; some pigment may be present on anal finfold and along junction of ventral interspinous bones and fin rays; pigment lighter *on left side of* larger specimens.[25]

JUVENILES

Metamorphosed by 35[7,16] to 50 mm.[5]

At 44 mm operculum with spines equally developed on both sides, at 59 mm no spines present; teeth not seen in just metamorphosed specimens,[25] conical and separated in young juveniles rather than incisor-like as in adults.[6,10]

Pigmentation: At 44 mm on postanal portion of body 7 broad pigment patches across median line of body; 5 broad patches with intermediate smaller patches on

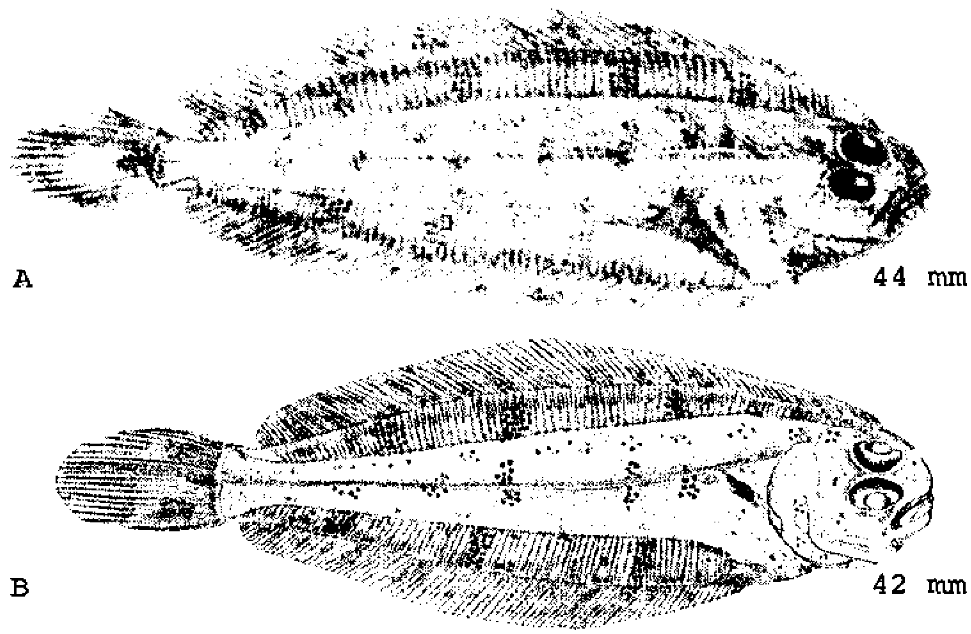

Fig. 95. *Glyptocephalus cynoglossus*, Witch flounder. A. Juvenile, 44 mm. B. Juvenile, 42 mm. (*A, Williamson, H. C., 1904: pl. 16. B, Petersen, C. G. J., 1904: pl. 2.*)

dorsal fin; 3 broad patches with smaller intermediate ones on anal fin; pigment retained on blind side.[25]

At 70–80 mm pigmentation is essentially as in adult.[26]

GROWTH

Growth rate varies between the sexes with the female growing faster and larger;[27] growth slower at greater depths.[28] Growth rates can be characterized by the formulas following—for males, $l_t = 60.93\ (1 - e^{-0.12\ (t-0.048)})$ and for females, $l_t = 83.77\ (1 - e^{-0.07\ (-0.42)})$ for Nova Scotia[18] and for males, $l_t = 30.86\ (1 - e^{-0.312\ (t-0.446)})$ and for females, $l_t = 36.11\ (1 - e^{-0.88\ (t-0.38)})$ where l_t equals length *in cm at time t for Irish Sea specimens.*[19]

AGE AND SIZE AT MATURITY

Mature as early as 4 or 5 years when 27–30 cm in Swedish waters,[28] males mature at 7 years when 37 cm and *females at 10 years when 44 cm in Nova Scotia,*[13] while other northwest Atlantic populations have males maturing at 6 years and 30 cm and females at 6 or 7 years and 36 cm.[22]

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Hippoglossus hippoglossus (Linnaeus), Atlantic halibut

ADULTS

D. (92)[2] (96)[26] 98–106 (110);[9,23] A. 69–84;[2] C. 17[13]–19 (15 branched);[9] P. 15[9,23]–17[13] (12 or 13 unbranched;[9]) V. 6;[13,23] scales about 160;[9,23] vertebrae 16 + 34[14,23]–35,[23] usually 16 + 34;[26] gill rakers 7–8 on lower limb of first arch.[9]

Body proportions as percent SL or HL: Head length 24–27 SL; greatest depth of body 36–38 SL; eye 14–20 HL.[9]

Body elongate with moderate caudal peduncle,[2] not *strongly compressed;*[15] head broad; mouth large; gape to

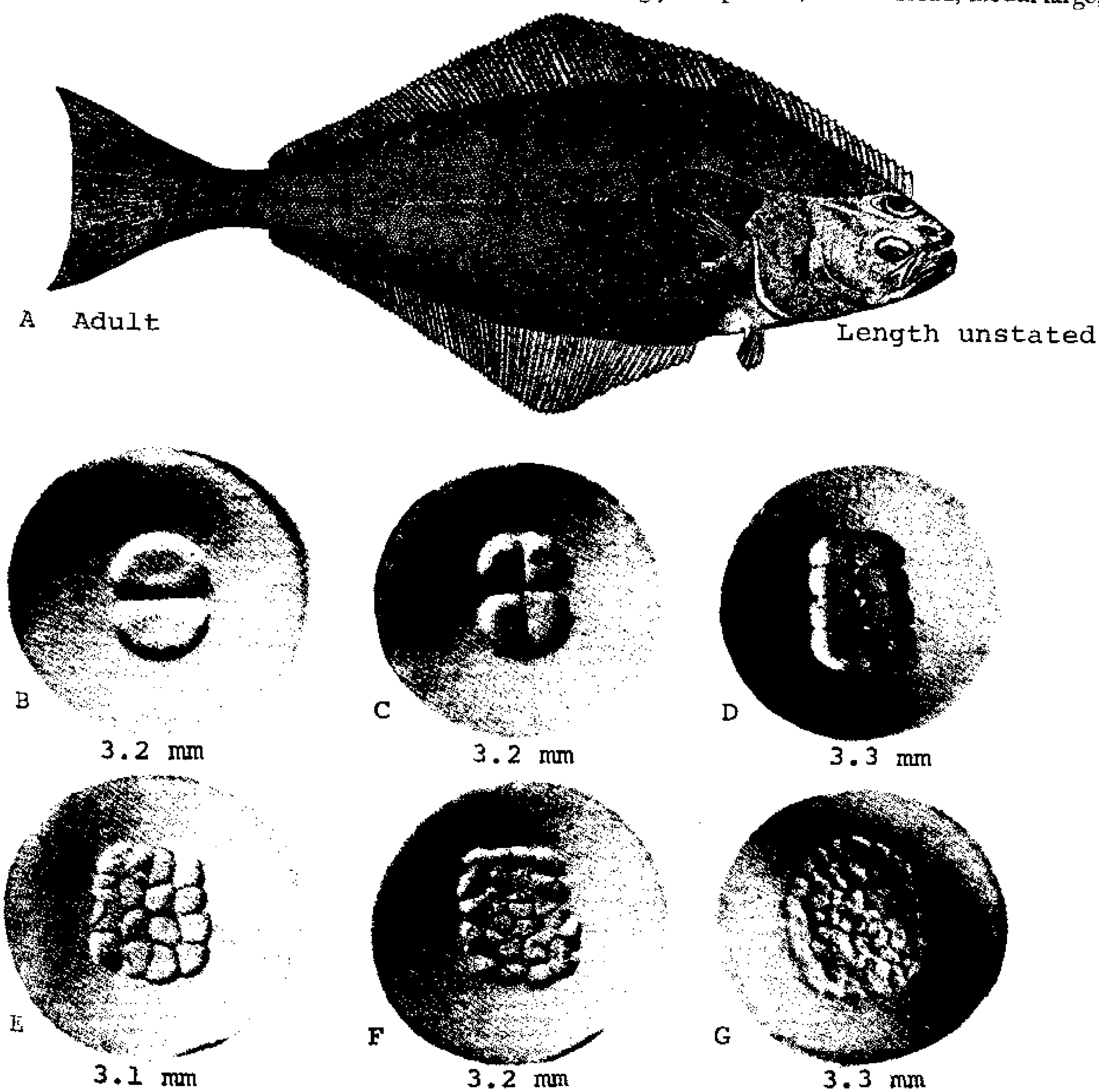

Fig. 96. *Hippoglossus hippoglossus,* Atlantic halibut. A. Adult, length unstated. B. Egg, 3.2 mm diameter, two-cell stage, 6 hours. C. Egg, 3.2 mm diameter, four-cell stage, 9 hours. D. Egg, 3.3 mm diameter, eight-cell stage, 12 hours. E. Egg, 3.1 mm diameter, 16-cell stage, 16 hours. F. Egg, 3.2 mm diameter, probably 32-cell stage, 20 hours. G. Egg, 3.3 mm diameter, early morula, 28 hours. (*A, Tracy, H. C., 1908: pl. 1. B-G, Rollefsen, G., 1934: fig. 1.*)

front of eyes [2] or middle of eye. Scales rounded in outline, mostly oval or nearly circular, secondary squamation present, many primary scales with a small boney plate on free end.[9] Lateral line arched above pectoral fin.[2] Dorsal fin origin over eye; [2,7] caudal fin large, concave; anal fin origin under that of pectoral fins; pelvic fin origin in advance of that of pectoral fin, under gill openings; [2] pectoral fin on eyed side pointed, that on blind side rounded.[7]

Pigmentation: Body color variable, chocolate to olive or slaty brown on eyed side; [7] younger individuals marbled or spotted with paler color,[9] older ones uniform, may be nearly black; [7] blind side white in younger fish, mottled or clouded with gray in older fish,[2,7] sometimes suffused with red.[2]

Maximum length: To 2.4 m.[2]

DISTRIBUTION AND ECOLOGY

Range: Both sides of Atlantic, in eastern Atlantic, from Iceland, Spitzbergen and Bear Island south along Norwegian coast to Scotland, Ireland, England, France and the Bay of Biscay, in western Atlantic from western Greenland [2] south to Virginia,[2,10,19] those south of Nantucket Shoals considered to be stragglers.[10]

Area distribution: New Jersey,[1] Virginia.[7,8,19]

Habitat and movements: Adults—inhabit hard bottoms of clay,[7,13] sand, gravel [7] or rock; [22] may move to deeper or shallower waters in response to season or temperature,[2,7] these movements not always apparent; most show little movement [25] but some individuals move 170–2700 km,[2] these individuals averaging up to 9.3 km/day; [24] reported from 0.6–15 C [7] but most common between 3 and 9 C; [25] reported from 9 [7]–920 m depth,[5] large individuals, especially females more likely to enter shallow water than intermediate size fish; [25] most common on offshore banks and continental slope.[15]

Larvae—smallest sizes (13–19 mm) over depths greater than 400 m,[3,7] 20–34 mm individuals more likely over shallower depths,[3] metamorphosing individuals may be over fairly shallow depths; [10] found at surface temperatures of 7.7–10.7 C and bottom temperatures of 0.1–8.6 C; [3] 13–19 mm, 5–50 m depth; 20–34 mm, 5–500 m depth,[3] 44 mm individual reported from more than 1655 m; [5] less than 20 mm length individuals found at or outside the 1000 m contour.[3]

Juveniles—inhabit sand bottoms,[3,24] move offshore with age; [7] carry out extensive migrations, one third of marked individuals in Faroe Islands migrated out; [26] small juveniles have only been reported from less than 50 m depth,[3,7] occasionally 7–8 cm individuals available to shore seines.[24]

SPAWNING

Location: Eggs have been found over depths of more than 1000 m,[3,5,7] other evidence points to spawning as shallow as 730 m; [2] spawning seems to occur within deep fjords or ocean bank pools covered by soft clay or mud [24] or along deep water edges of banks.[25]

Season: Spawns in late winter and spring,[2,3,4,6,7,16,22,24,25] in Scottish waters may stretch into June,[4] in American waters may continue into September,[7] peak in April [3,16] or early May.[16]

Time: In aquaria spawning is nocturnal.[3,18]

Temperature and salinity: Spawning temperature 4–7.5 C [3] or 3–8 C [24] and salinity probably 35 ppt.[8]

Fecundity: A 91 kg female produces over 2 million eggs.[27]

EGGS

Location: Pelagic but not at surface, variously reported in the depth range from 55–91 m,[7] 300–400 m [21,24] or about 700 m,[3] Norwegian eggs reported to be most common at 300–400 m but also occurring between 100 and 180 m.[24]

Unfertilized eggs: (Shrunk by preservation in picric acid) diameter of 3.07–3.81 mm; [11] others listed as 3.0–3.5 mm,[18] 3.1–3.8 mm,[12] 3.429—3.762 mm; pinkish; [11] yolk colorless; [15,18] capsule thin; [11,15] very little perivitelline space.[16]

Fertilized eggs: Spherical,[2] clear; [24] diameter variously given as 3–3.8 mm,[11,24] 3.1–3.6 mm,[2] 3.2 mm,[21] 3.0–4.25 mm [6] or 3.39–3.57 mm; [3] chorion thick, smooth, shiny [3] and tough; [12] yolk clear with a slight yellowish tinge; perivitelline space small.[3,21,24]

EGG DEVELOPMENT

Incubation period of 16 days at 6 C.[2,7,21]

First cleavage at 6 hours after fertilization, other cleavages at 3 hour intervals at 6 C; neurulation occurring at 6 days 9 hours; 9 somites visible at mid-body at 7 days 13 hours.[21]

YOLK-SAC LARVAE

Hatch at 6–7 mm [7] or 6.5–7 mm; at 8.5 mm (6 days) still having a large yolk mass.[21]

Pigmentation: No pigment prior to tenth day after hatching,[7,21] first pigment noted is eye pigmentation.[21]

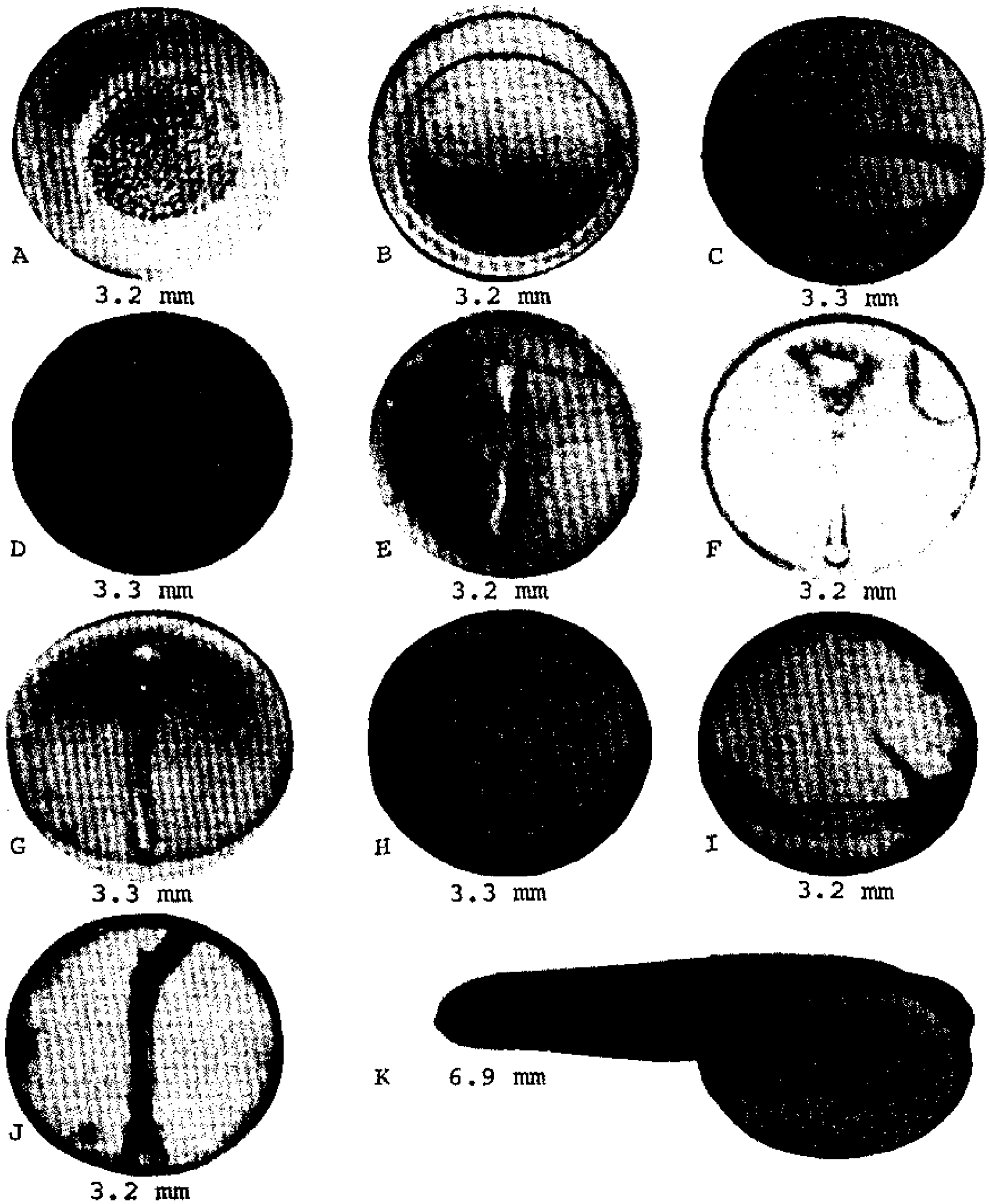

Fig. 97. ***Hippoglossus hippoglossus*, Atlantic halibut.** A. Egg, 3.2 mm diameter, late morula, 1 day 9 hours. B. Egg, 3.2 mm diameter, blastoderm beginning to spread, 4 days 9 hours. C. Egg, 3.3 mm diameter, blastoderm spread further, 4 days 21 hours. D. Egg, 3.3 mm diameter, neurulation occurring, 5 days 9 hours. E. Egg, 3.2 mm diameter, later neurulation, 6 days 9 hours. F. Egg, 3.2 mm diameter, brain differentiating, somites visible, 7 days, 13 hours. G. Egg, 3.3 mm diameter, somites visible for most of the length, 10 days. H. Egg, 3.3 mm, side view of embryo at about the same stage as that in the previous figure, 10 days 11 hours. I. Egg, 3.2 mm diameter, late embryo, 15 days 11 hours. J. Egg, 3.2 mm diameter, embryo just prior to hatching, 16 days. K. Yolk-sac larva, 6.9 mm TL, freshly hatched. (*A-K, Rollefsen, G., 1934: figs. 1, 2, 3.*)

LARVAE

Reported from 13.5 mm to 34 mm.[26]

D. 100 at 20 mm TL,[20] 103–104 at sizes above 22 mm;[15,17,26] A. 76 at 20 mm,[20] 82–83 at 22–23 mm,[26] 88 at 32 mm; C. 22 at 32 mm. Gill cover with a row of spines at 32 mm,[15,17] these not visible at 34 mm.[26] Body ovate, oblong,[20] caudal peduncle short at 34 mm;[26] head with a deep angular depression between eye and upturned nose,[20] lower jaw long and straight. Eye begins migration at 16 [26] or 20 mm,[20] reaches mid-dorsal ridge by 22–23 mm, on the ridge by 27 [26] to 34 mm;[6] over the ridge but still touching midline at 34 mm, becoming ovate at 34 mm.[26] Dorsal, anal and caudal fin rays appearing at 13.5 mm;[7,26] caudal fin becoming broad, truncate at 34 mm;[26] pectoral fin without formed rays up to 20 mm;[26] 30.1 mm,[3] 32 mm [17] or 34 mm; pelvic fins not present at 13.5 mm,[26] present as finfolds at 20 mm,[20] forming at 22 mm. Notochord flexion beginning at 13.5 mm, flexed to 30° by 16.2 mm.[26]

Pigmentation: At 13.5 mm pigment in no characteristic pattern, not particularly conspicuous; small melanophores in lines between myotomes; ventrolaterally about 3-4 longitudinal rows, dorsolaterally only one extends from vent to tail base; no external pigment mediolaterally; small melanophores on dorsal and anal fins, especially near margin; very little pigment on trunk or head; a conspicuous ventral median row of minute preanal melanophores.

From 16.2 to 20 mm, brain behind eye with some distinct round melanophores; gastric region with a few scattered distinct specks; small spot on angle of lower jaw; eyes light blue; some small reddish spots on edges between

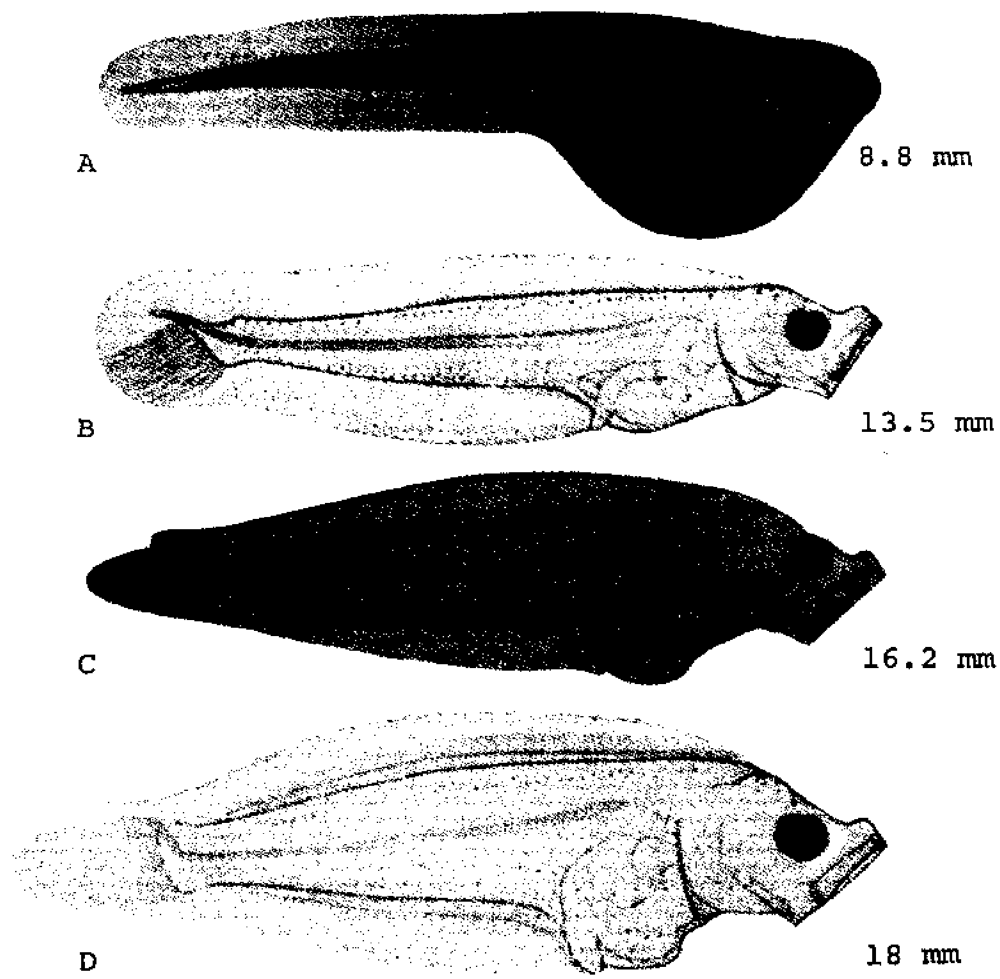

Fig. 98. *Hippoglossus hippoglossus*, Atlantic halibut. A. Yolk-sac larva, 8.8 mm TL, 6 days after hatching. B. Larva, 13.5 mm, notochord flexion occurring. C. Larva, 16.2 mm, notochord flexion still in process. D. Larva, 18 mm, notochord flexion complete or nearly so. (*A, Rollefsen, G., 1934: fig. 4. B-D, Schmidt, J., 1904: pl. 1.*)

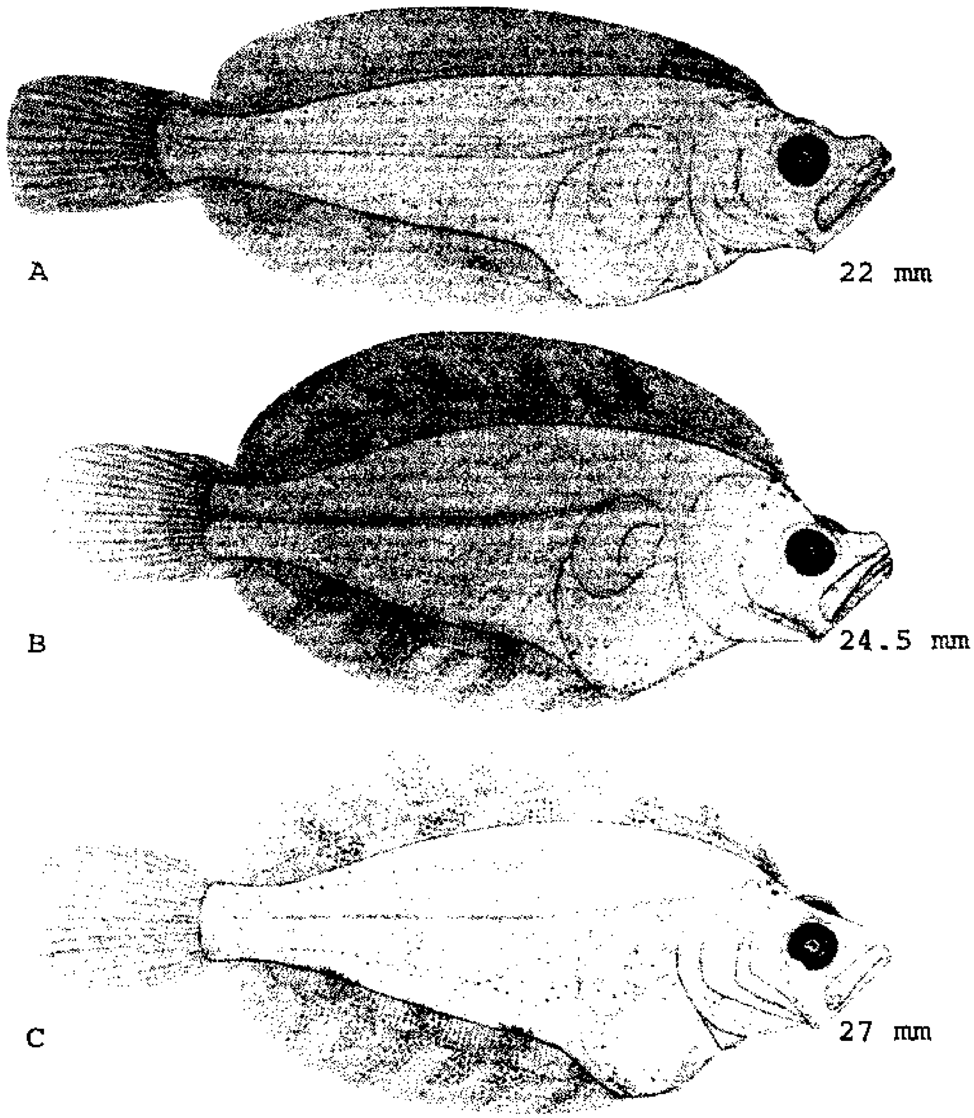

Fig. 99. ***Hippoglossus hippoglossus***, Atlantic halibut. A. Larva, 22 mm, fins near completion, pigment bars appearing in vertical fins, eye migrating. B. Larva, 24.5 mm, body becoming deeper. C. Larva, 27 mm, pigment bars and blotches on sides becoming visible. (*A-C, Schmidt, J., 1904: pl. 1.*)

myotomes.

At 22–23 mm there is a tendency for pigment to gather into groups on rays and interspinous bones, 3 such groups visible on anal fin.

At 24.5–25 mm 3 conspicuous spots visible in anal fin and one at anus; small intermediate spots on rays, 4 spots on interspinous bones and rays, smaller secondary patches on rays; some melanophores on pelvic fins; no spots on pectoral or caudal fins; left side not so strongly pigmented as right.

At 27 mm 5 groups distinct on dorsal fin besides secondary spots on rays; some mediolateral pigment.

At 29.5 mm 4 transverse patches of pigment on body between the principal spots on the fins; caudal fin unpigmented.

At 34 mm right side clearly more pigmented than left; sides marbled; 2 faint round patches on proximal portion of caudal fin.[26]

Fresh material almost covered with small, numerous orange-red erythrophores; over brain small scattered erythrophores, smaller than melanophores of that region; over whole head erythrophores small and few, grouped

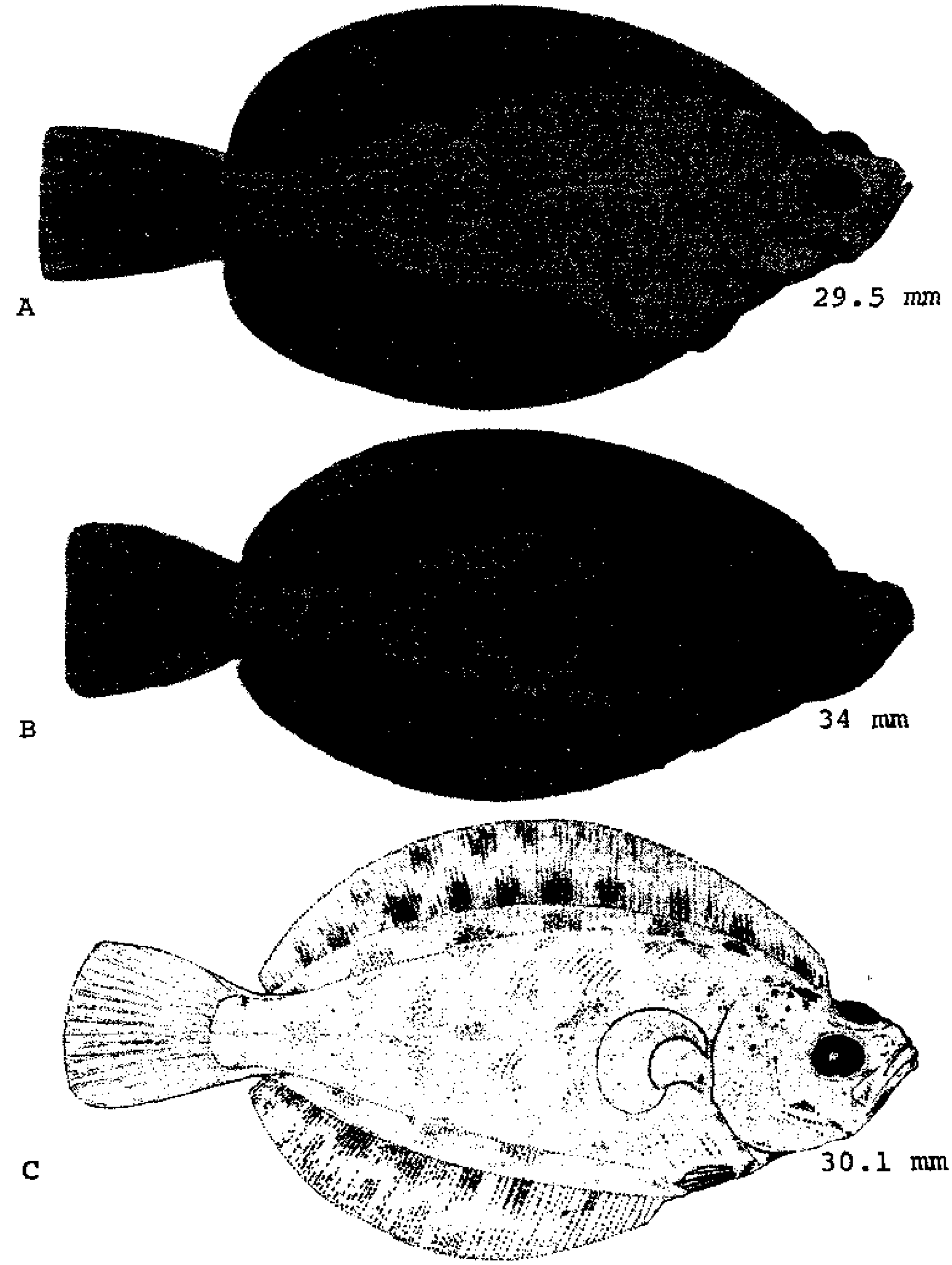

Fig. 100. *Hippoglossus hippoglossus*, Atlantic halibut. A. Larva, 29.5 mm, eye nearing dorsal position. B. Larva, 34 mm, eye well onto dorsal ridge, color pattern intensified. C. Larva, 30.1 mm, approximately same stage as previous figure, but deeper bodied. (*A, B, Schmidt, J., 1904: pl. 1. C, Tåning, A. V., 1936: fig. 3.*)

into spots on snout and tip of lower jaw, also on cleithrum; few erythrophores on gut and abdominal wall; on body and tail erythrophores mostly on myosepta but may be scattered on myomeres mediolaterally; erythrophores more numerous on body anteriorly and ventrally; erythrophores also on interspinous membrane but more numerous basally; no erythrophores on caudal fin except for a spot ventrally on base.[3]

JUVENILES

Smallest reported as 44 mm.[27]

A

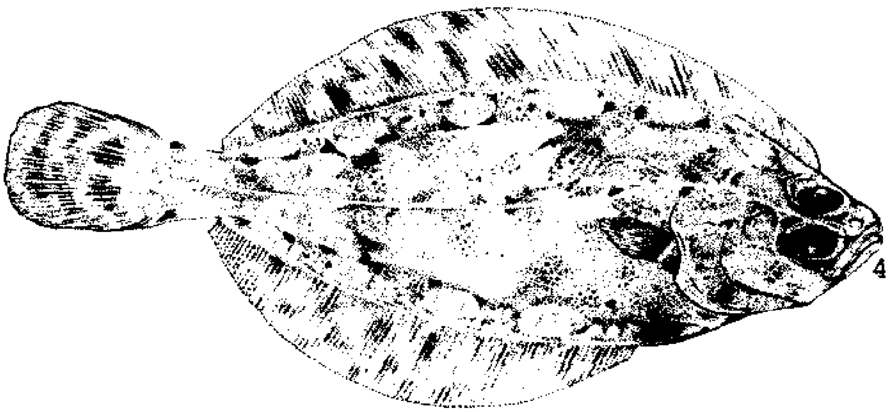

Fig. 101. *Hippoglossus hippoglossus*, Atlantic halibut. A. Juvenile, 47.4 mm. (*A, Tåning, A. V., 1936: fig. 4.*)

Between 47 and 411 mm SL body proportions change as follows: depth 35.7% to 36.2% SL, head length 30.4% to 26% SL, right eye 7.5% to 4.4% SL, and preanal length 38.2% to 33.3% SL.[3]

Pigmentation: At 47.4 mm 6 dorsal and 5 ventral pigment patches, base of caudal fin with 2 distinct pigment spots, melanophores on braincase practically disappeared, caudal fin now pigmented, lateral line distinctly marked; larger specimens black and chestnut brown [3] or dull olive marbled with darker blotches and reddish spots on body and fins.[15]

GROWTH

Growth rates variable, within Icelandic waters there are at least three populations with quite different growth rates;[5] growth rates may be from 120[21] to 650 mm/year;[24] females grow faster than males, this difference not appearing until the 4th year,[27] the 9th or 10th year or even as late as the 15th year.[25]

AGE AND SIZE AT MATURITY

Females mature at 9–10 years,[7] 7–8 years with some delaying until 11 or 12,[4] 10–12 years[25] or 8–18 years;[24] males mature at 5–10 years,[4] 7–11 years[25] or 7–17 years;[21] females may mature over range of 90 to 129 cm; males from 70–119 cm.[25]

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Limanda ferruginea (Storer), Yellowtail flounder

ADULTS

D. 73–91; A. 55–68;[4] C. 16[13] or 18 (12 branched);[14] P. 10;[1] V. 6;[13,14] scales 88[14]–100;[2,9] gill rakers moderate length, weak,[2,14] 10–12 on lower arch;[14] teeth $\frac{11\text{–}14 + 30\text{–}34}{10\text{–}16 + 30\text{–}42}$.[14]

Body proportions expressed as percent SL or HL: Body depth 41.7–44.4 SL; head 23.5–26.7 SL;[14] eye 16.7[4]–22.2 HL;[2] lower jaw 35.7–37.5 HL.[14]

Body ovate-elliptical, strongly compressed;[2,4] caudal peduncle short, deeper than long;[2] head with a projecting snout,[2,4] upper profile with a concavity in front of eye;[2,4,14] mouth small; gape ending before eye,[4] below anterior edge of portion of eye.[5,14] Teeth small, conical, close-set, uniserial on each side of jaw.[4] Scales imbricate, nearly uniform, strongly ctenoid on ocular side, cycloid on blind side.[2,4] Lateral line with a low arch over pectoral fin.[2] Dorsal fin origin just behind posterior nostril of blind side and above anterior portion of eye;[14] caudal fin rounded;[2,4] anal preceded by a short, sharp, forward facing spine,[5] origin under tip of gill flap; pelvic fins in advance of pectorals.[4] Intestine with 3 or 4 irregular coils, 3 + 1 long pyloric appendages.[13]

Pigmentation: Background color variable, slaty olive tinged with reddish,[5] brownish olive tinged with green[13] or brownish olive,[2,4,9] reddish irregular spots;[2,4,5,13] blind side white[5,13] or yellow,[2,4,9] margins of dorsal fin, anal fin and caudal peduncle yellow;[2,4,5,13] pupils black; iris golden.[13]

Maximum size: To 55 cm[2] or 60 cm.[4]

DISTRIBUTION AND ECOLOGY

Range: Northern shores of Gulf of St. Lawrence to Virginia.[2,5]

Area distribution: Chesapeake Bight,[1] Delaware Bay[3] and lower Chesapeake Bay.[2]

Habitat and movements: Adults—on bottoms of sand or sand and mud;[4,5] occur in localized populations which may make short, seasonal migrations;[5,10] found from −1.0[16] to 12.2 C,[5] concentration at 3.0 C;[16] reported from 9 m[4] depth to 219 to 238 m,[5,16] most common in depths less than 73 m[4,5] but more than 37 m.[4]

Larvae—pelagic, movements largely limited to those of the water mass they are in, movements not extensive; reported from 4.1 C[7] to 20 C.[10] 90% of small larvae in range 4.1–8.9 C;[7] peaks of abundance at surface at night, at 10 m[10] or 20 m in daytime (WGS).

Juveniles—no information.

SPAWNING

Location: Eggs most common over depths of 45–75 m.[5]

Season: Prolonged, with each female spawning more than once,[2] mid-March[8] to September,[10] peaks in April to June in New England,[4,10] latter half of June and July in Canada.[4,16]

Temperature: Probably at 5–7 C[10] or 4.5–8.1 C.[7]

Fecundity: 400,000 to 4.8 million eggs. Also described by formula:[15]

$F = 4.69 \log L - 1.45$, where: F = egg number, L = length in cm.

EGGS

Location: Pelagic, near surface.[2,4,5,6,10]

Fertilized egg: Spherical;[2,4,5] transparent;[2,5] germinal disc very pale buff in life;[5] .79–1.01 mm, average .88 mm[6,8] or .9 mm; surface with minute striations, perivitelline space narrow.[5]

EGG DEVELOPMENT

Three groups of pigment just prior to hatching, on head, region of vent,[5] halfway between vent and tip of tail.[5]

Incubation period: 5 days at 10–11 C.[2,4,5]

YOLK-SAC LARVAE

Average 2.75 mm at hatching, 2.00–3.52 mm range.[6,8]

Anus immediately behind yolk sac.[8]

Pigmentation: A faint ventral row of very fine pigment granules, a fine scattering of pigment may or may not be apparent on head and one or two small patches on tail.[6]

LARVAE

From at least 4[6] to 14[5,6] mm.

D. 76 at 14 mm; A. 59 at 14 mm;[5] caudal rays formed by 10 mm.[6]

Pigmentation: Four vertical bars present by 5.5 mm, first at pectoral fin and rest spaced evenly, a row of pigment along dorsal margin of gut cavity and some scattered pigment on back of head.[6]

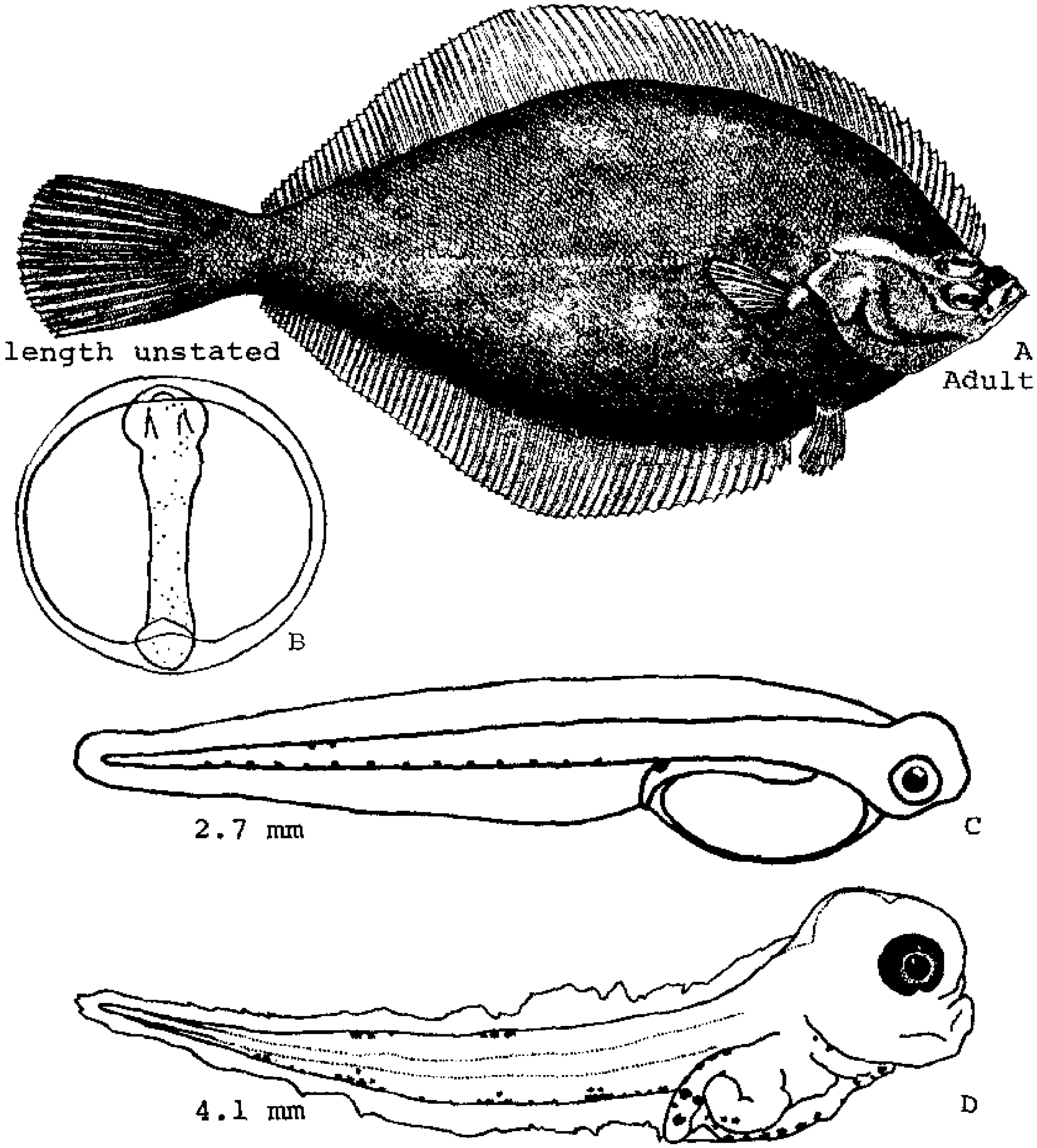

Fig. 102. *Limanda ferruginea*, Yellowtail flounder. A. Adult, size unstated. B. Egg, diameter unstated. C. Yolk-sac larva, 2.7 mm, color pattern forming. D. Larva, 4.1 mm. (*A, Bigelow, H. B., and W. C. Schroeder, 1953: fig. 136. B, Bigelow, H. B., and W. W. Welsh, 1925: fig. 252. C, D, Miller, D., 1958.*)

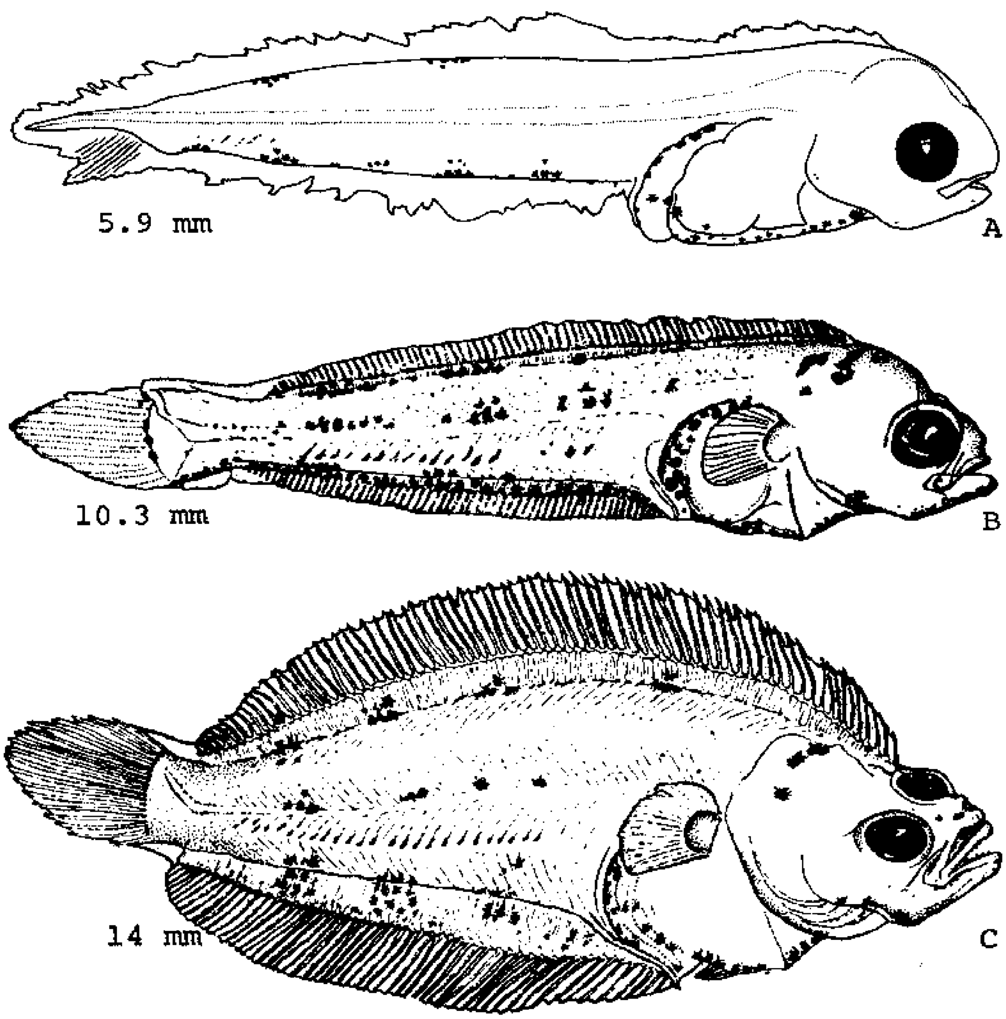

Fig. 103. *Limanda ferruginea,* Yellowtail flounder. A. Larva, 5.9 mm, caudal rays forming. B. Larva, 10.3 mm, dorsal and anal rays nearly all formed. C. Larva, 14 mm, migration of eye nearly complete. (*A, Miller, D., 1958. B, C, Bigelow, H. B., and W. W. Welsh, 1925: figs. 253, 254.*)

JUVENILES

From 14 mm [2] to at least 26 cm.[10]

GROWTH

Canadian stocks slower growing than U.S. stocks but reach a greater length and age.[11] Off Canada both sexes have same growth rate for the first seven years,[4] off southern New England sexes have same rate for only two years.[12] Attain length of 13 cm at end of first year,[5] 26 cm in 2 years off southern New England, 25 to 30 cm on Georges Bank.[12]

AGE AND SIZE AT MATURITY

Off Newfoundland 50% of males mature by 5 years, females by 6 years; [16] some mature as young as 2 to 3 years. Off New England males mature before 26 cm TL, 50% of females mature by 32 cm TL; [10] off Nova Scotia females mature over the range 36 to 45 cm,[11] 50% mature at 37.4 cm; [16] males over range 30 to 35 cm,[11] 50% mature at 31.3 cm.[16]

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Pseudopleuronectes americanus (Walbaum), Winter flounder

ADULTS

D. 59 [15]–76; [5,15] A. 44 [5]–58; [5,15] C. 19, 13 branched; P. (ocular side) 10–11, 5–7 branched; [18] scales 77 [6]–89; [18] vertebrae 10 + 26; [18,21] gill rakers short, 7 or 8 on lower limb; teeth $\frac{0\text{–}2 + 10\text{–}15}{0\text{–}2 + 10\text{–}17}$; 3 + 1 pyloric caeca.[18]

Body proportion expressed as percent SL or HL: Body depth 38.5–50 SL; head length 21.7–27.8 SL; [18] eye 20.4–32.8 HL; snout 19.2–21.7 HL.[6]

Body elliptical with dorsal and ventral outlines about evenly curved,[6] caudal peduncle heavy; [5] head small with a pointed snout,[6] upper profile straight [18] or slightly concave over eyes; [5,18] mouth small with asymmetrical jaws; [6] gape to anterior margin of lower eye [6,18] or short of it.[5,15] Teeth small, incisor-like, uniserial, present on both sides but more numerous on blind side [5,15] or no teeth in right upper jaw.[6,14] Scales small, strongly ctenoid on eyed side, extending onto fin rays; less strongly ctenoid, almost smooth on blind side.[6] Lateral line straight or, at most, slightly arched at level of pectoral fin.[24] Dorsal fin origin over anterior part of upper eye; [6,14,18] caudal fin round; pelvic fins small, origin under pectoral fin base; anal fin origin about one eye diameter behind base of pectoral fin [6] or under middle of pectoral fin base.[5]

Pigmentation: Body color variable reddish brown; [5,14,21,41] olive green [6] to almost black,[5,14] able to change coloration somewhat; [14] plain or mottled; [5,14,21,41] fins nearly plain; [21] underside whitish [5,6,14,21,41] with underside of peduncle whitish or yellowish.[5,14]

Maximum size: Reported to reach 64 cm [5,27] but most are under 40 cm.[4]

DISTRIBUTION AND ECOLOGY

Range: Northern Labrador to Georgia.[5,14,15,19]

Area distribution: Throughout Chesapeake Bight [8,11] and Chesapeake Bay.[6]

Habitat and movements: Adults—mud or grassy bottoms preferred [14,15,43] but also found on sand or clay [14,15,41] or even gravel [14,15] and on offshore banks.[15] Overwinter in deeper channels of inlets [10] or offshore [5,10,12,27] with these movements being just enough to reach desired temperatures and with return to shore or shoal waters coinciding with warming to 10 C; [27] most movements encompass short distances [5,17,19,24,30] and are nearly random; [33] reported from freshwater to seawater [6,15] but salinities below 15 ppt are lethal over long periods of time; [30,32,42] reported from −1.5 [34] to 28 C [12] but avoid waters cooler than 0 C [36] or warmer than 14–15 C; [27] occur from shore to 128 m [5,19] but not common in water deeper than 36 m.[24]

Larvae—pelagic but strongly bottom oriented before completion of metamorphosis,[25] yolk-sac larvae on bottom when not actively swimming; [26] seldom encountered on finely divided mud bottoms or among dense vegetation, mostly on sand or sand-silt bottoms.[27] It is believed that those flushed out of the estuary to sea have very little chance of survival to metamorphosis.[19,26] In late spring there may be movement from upper estuary to lower.[26] Known from 3.5 to 27.7 ppt salinity [27] with peak abundance between 6 and 15 ppt; [9] −0.8 [3] to 18 C with most present in 4–13 C; [9] newly hatched larvae within a few centimeters of bottom [27] in depths less than 37 m; occur within 25 km of shore, concentrations near mouths of estuaries.[19]

Juveniles—benthic,[27] remain in estuaries until 2+ years old,[23] also on sandy shores; [43] stay inshore except to avoid temperature extremes; [10,27,45] salinity 4–30 ppt,[45] normal growth at 20 ppt but not 30 ppt; [1] 0–25 C,[45] incipient lethal temperature −1.0 to −1.5 C,[27] smaller individuals more tolerant than adults to higher temperatures,[28] exhibit normal growth only between 12 and 16 C,[1] avoid 30 C; [45] age classes I and II mostly at depths less than 18 m except in colder weather when they are at depths 18 to 37 m.[30]

SPAWNING

Location: Occurs inshore on sandy bottoms,[14,15,31] in estuaries; [15,19] at depths from 1.8 to 3.6 m; [14,15,17] reported to have highest hatching success where eggs are laid on algal mats; [48] there are a number of independent local spawning populations.[19]

Season: Occurs from mid-December to May,[17] peak in March from Chesapeake Bay to Cape Cod, April in southern New England.[19]

Spawning time: Between 2200 and 0330 hours.[25]

Temperature and salinity: Spawning between 1–10 C, peak at 2–5 C; [26] ovulation not occurring above 6 C; [46] salinity between 11.4 ppt [14] and 33 ppt.[15]

Fecundity: Maximum number of eggs reported 3.329 million.[27] Average fecundity 500,000 eggs/small female.[14,15,27] Described by formulae:

Log fecundity (thousands of eggs) = 1.1272 + 0.7701 log total length (mm)—0.04877 log weight (grams)—1.7782 log gonad weight (grams).

Log fecundity (thousands of eggs) = 2.6712 + 1.1383 log weight (grams).[40]

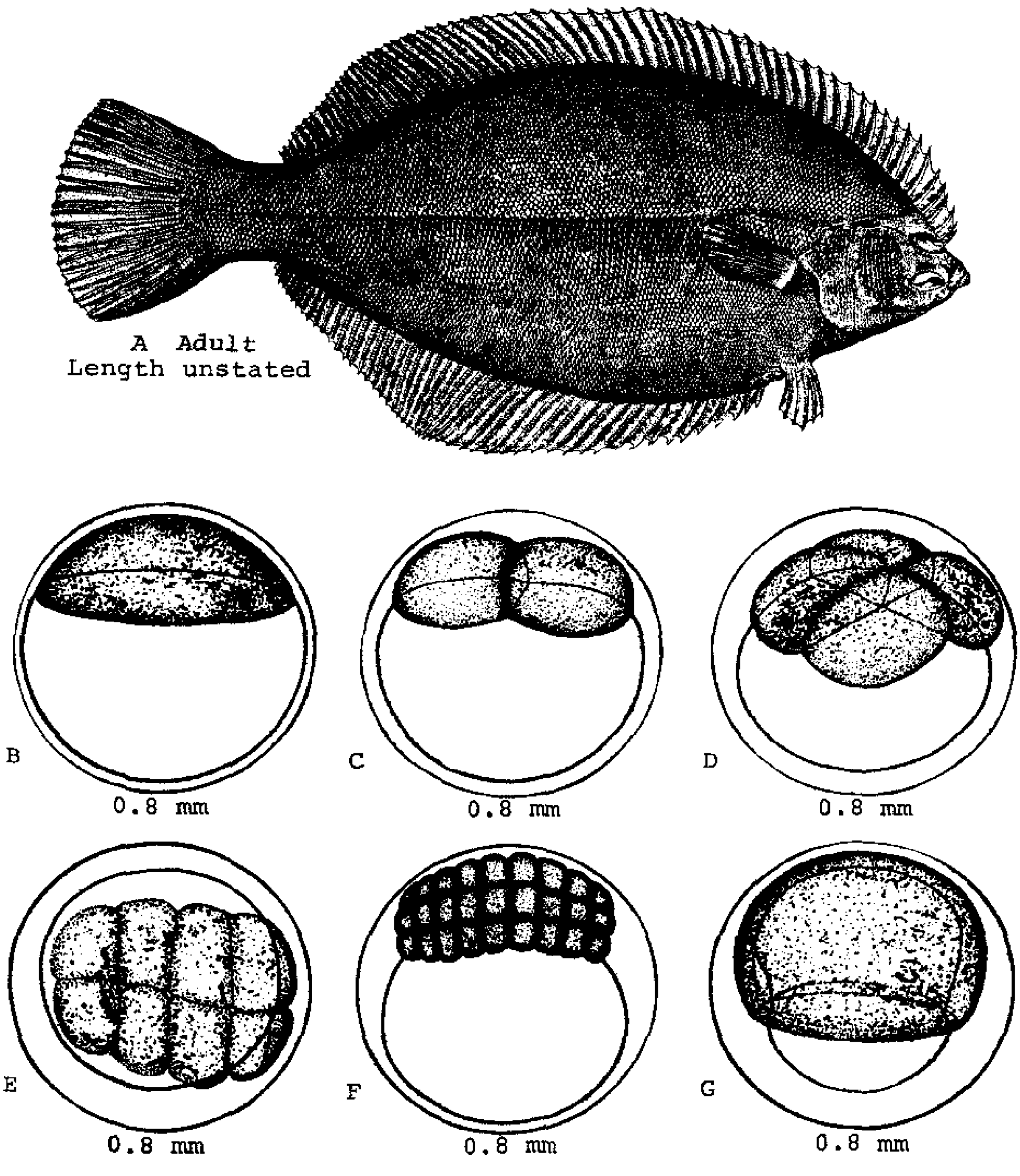

Fig. 104. *Pseudopleuronectes americanus*, Winter flounder. A. Adult, length unstated. B. Unfertilized egg, 0.8 mm. C. Egg, 0.8 mm, two-cell stage. D. Egg, 0.8, four-cell stage. E. Egg, 0.8 mm, eight-cell stage. F. Egg, 0.8 mm, morula. G. Egg, 0.8 mm, embryo differentiating, embryonic shield overgrowing yolk. (*A, Tracy, H. C., 1908: pl. 6. B-G, Breder, C. M., Jr., 1923: fig. 274.*)

EGGS

Location: Eggs have a specific gravity of 1.085–1.095 compared to 1.010–1.024 for the water,[2,26] therefore lie on bottom;[5,14,17,19,31] found in about 30 cm water over mud flats;[13] eggs discharged by groups of circling fish so that they are spread over an area;[25] occur singly and in aggregates of 2, 3 and 4.[13]

Unfertilized eggs: .33–.93 mm.[27]

Fertilized eggs: Spherical;[5] sizes from .71[40] to .96 mm,[26] average 0.80 mm;[2,47] membrane surface "resembled fine grained leather in texture";[40] adhesive;[2,12,37] yolk colorless, with finely tuberculate surface.[40]

EGG DEVELOPMENT

At 20.6 C, first cleavage at 2 1/4 hours after fertilization. At 24 hours, blastoderm broken up into a high number of cells; at third day, neural tube formed; by the end of the sixth day, somites forming at mid-body, Kupffer's vesicle formed, optic anlagen visible; by the end of the ninth day, optic cup complete, xanthophores sprinkled over body, these punctulate; on the fifteenth day, concentrations of chromatophores in a vertical band in the caudal region, heart beating, cephalic region finely tuberculate, *hatching beginning.*[35]

Eggs develop to hatching over the range −1.8 to 18 C, but with lower hatching success above 10 C,[47] in another

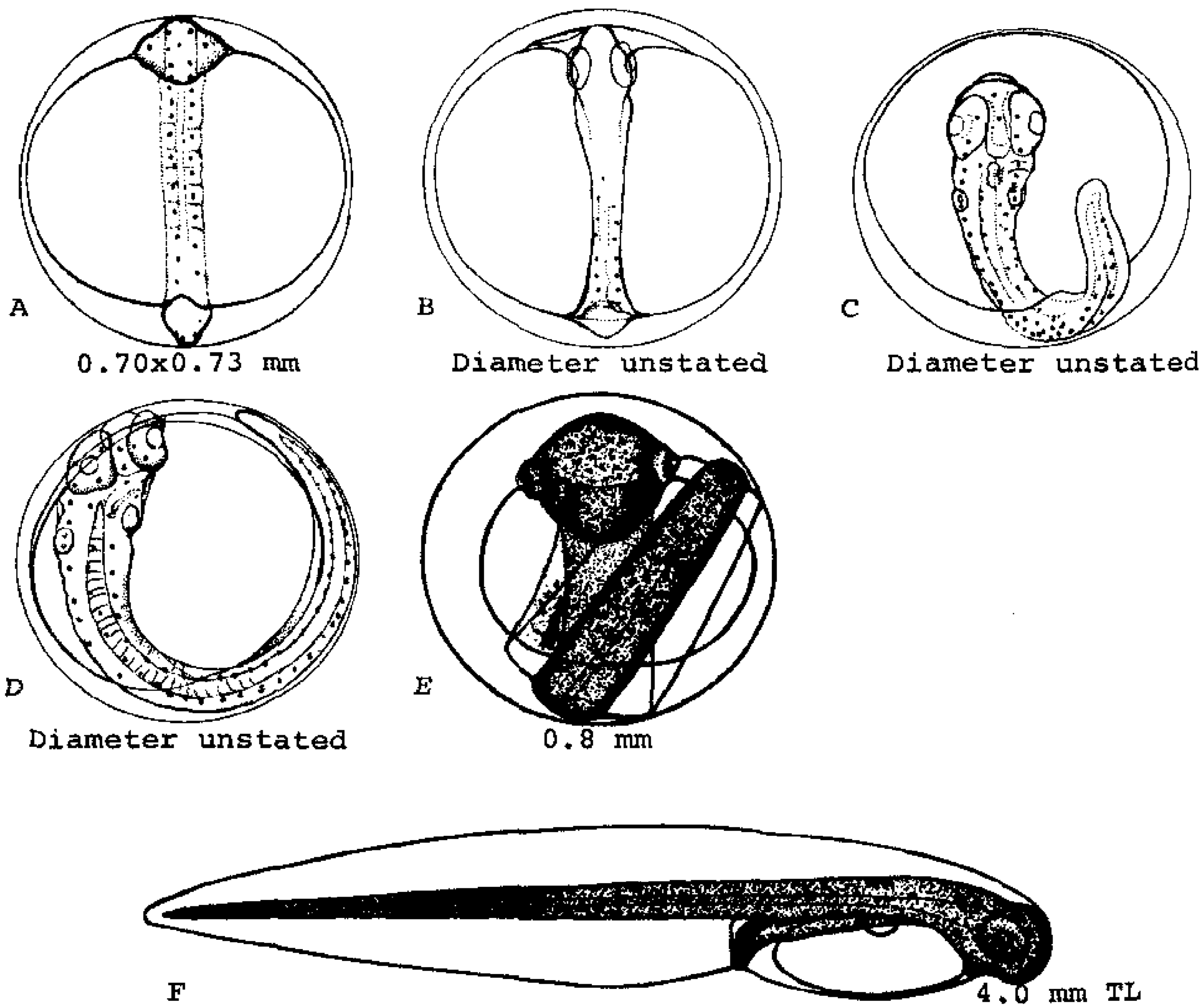

Fig. 105. *Pseudopleuronectes americanus,* Winter flounder. A. Egg, 0.70 mm x 0.73 mm, ventral view, eye cup visible, pigment present, somites visible. B. Egg, diameter unstated, dorsal view, about the same stage as fig. A. C. Egg, diameter unstated, advanced embryo. D. Egg, diameter unstated, near hatching. E. Egg, 0.8 mm, ventral view, near hatching. F. Yolk-sac larva, 4.0 mm TL, newly hatched. (*A-D, Agassiz, A., and C. O. Whitman, 1885: pl. 16. E-F, Breder, C. M., Jr., 1923: fig. 274.*)

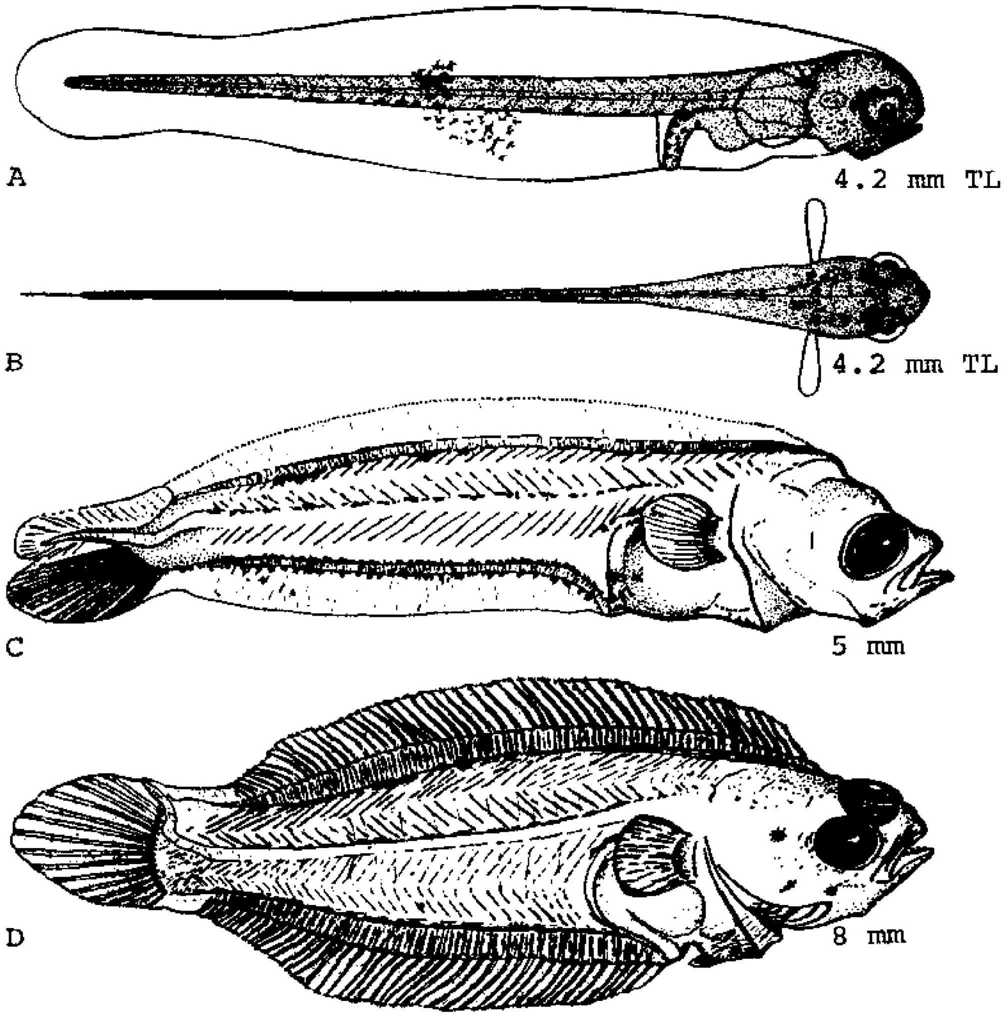

Fig. 106. *Pseudopleuronectes americanus*, Winter flounder. A. Larva, 4.2 mm TL, 19 days old. B. Larva, 4.2 mm TL, dorsal view, 19 days old. C. Larva, 5 mm, fin rays differentiating, flexion occurring. D. Juvenile, 8 mm. (*A-B, Breder, C. M., Jr., 1923: fig. 274. C-D, Bigelow, H. B., and W. W. Welsh, 1925: fig. 260.*)

set of experiments decreasing survival as temperature increases from 3 C; [48] hatching occurs over the range 4.5 [13] ppt to 40.0 ppt salinity,[48] hatching takes place at 35 ppt, but rate of development retarded; [47] optimum survival and developmental rates dependent on temperature-salinity combination but this optimum lies somewhere in the range between 15 and 35 ppt salinity.[48]

Incubation period: *Either die or hatch by 16–24 days at* 0 C, average 21 days; [13] 25 days at 3 C; [48] 24–28 days at 4-5 C, average 26; 17–19 days at 12–17 C, average 18; [13] 15-18 days at 2.7–3.3 C [14] or 17–18 days.[39,41]

YOLK-SAC LARVAE

Hatch at 2.3 mm [26] to 3.5 mm,[18] yolk absorbed by 5 mm.[14,16]

At hatching almost transparent except for eyes which may or may not be chrome yellow and a vertical pigment band on tail, also pigmentation around vent.[16]

LARVAE

From 5 mm [14,16,20] until eye migration complete at 6.5 *mm*,[16] *8 mm* [14] or 9 mm.

Dorsal fin rays 60–76 at metamorphosis, anal 45–58; [20] eye migration completed over a 3 day period; [7] otoliths not ossified before left eye reaches median position (about 7 mm); [45] at 5 mm, position of finfold similar to that of adult fins, notched between incipient dorsal and caudal by 5.8 mm; notochord flexes by 5.8 mm.[16]

Pigmentation: Patch of pigment at angle of lower jaw; 4

large spots ventral to heart; line of pigment along dorsal side of notochord and corresponding lines along dorsal and ventral borders of body, spots along ventral borders more expanded than others in lines; patches variable on abdominal region and over heart; dorsal finfold unpigmented or with a few scattered spots with no fixed arrangement; two nearly unbroken lines in ventral finfold; some expanded erythrophores on ventral finfold.[16]

JUVENILES

Smallest size 6.5 mm [16] or 6 to 9 mm.[27]

Finfold remnants still observable at 6.5 mm.[16]

Pigmentation: At 6.5 mm brain and spinal chord distinctly outlined superficially by pigment spots; pigment of left side decreasing; at 8 mm right side completely pigmented, left side has lost pigment except for a few scattered spots; at 20 mm all pigment lost on left side; [16] right side olive brown spotted with red.[41]

GROWTH

Growth varies from locality to locality,[38] northern populations grow more slowly than southern [27,39] with a seeming cline.[39] Females grow faster; [29,38] in Rhode Island grow 10 mm/mo. for first summer; [44] in Connecticut reach about 70 mm at end of first year and 160–170 mm by end of second.[45]

AGE AND SIZE AT MATURITY

May mature at 3 years; [22] in Newfoundland all are mature by 9 years, some males by 4 years, some females by 5 years. In Newfoundland 50% of all males are mature by 21 cm, 50% of all females are mature by 26 cm.[39]

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Trinectes maculatus

soles
Soleidae

FAMILY SOLEIDAE

These fishes, like the Pleuronectidae, have both eyes on the right side of the body. Thus they are shown facing right unlike other species in these volumes. Adult soles are easily distinguished from the right-eyed flounders by having their preopercular margins covered with skin and not free. Soles are primarily tropical and temperate and are represented in the area by a single species, *Trinectes maculatus* (Bloch and Schneider), the northern hogchoker. Most soles are marine or estuarine but many, the hogchoker included, are capable of invading freshwater. Most soles which invade freshwater, the hogchoker again included, are unable to maintain all life stages in freshwater; however, in South America some are largely confined to freshwater.

Sole eggs can be differentiated from bothid or pleuronected eggs by the larger number of small oil droplets, which are often in irregular clusters, unlike the scattered droplets in cynoglossid eggs.

Trinectes maculatus (Bloch and Schneider), Hogchoker

ADULTS

D. North American population 50 [6,15,19]–56,[6,19] South American population 56–57; [4] A. 36 [6,19]–46; [15] P. wanting, but some specimens with a single ray; [16] C. 14–15 (JWT) or 16; [11] scales 66–75; [6,15] vertebrae 8 + 20 [15] or 9 + 19–20.[11]

Body proportions as percent SL: Head length 21.3–28.8; depth 54.3–57.2; eye 2.1–2.7.[4]

Body broad, dorsal and ventral outlines about evenly convex; [8] short, broad caudal peduncle (JWT); head short with a blunt snout; mouth small, terminal, jaws considerably curved,[6] upper jaw slightly longer (JWT); lower lip fringed; [15] maxillary extends under anterior half of lower eye.[5,6] Teeth in villiform bands, present only on blind side.[6] Scales small, strongly ctenoid on both sides.[5,6,8,19] Lateral line indicated by a narrow stripe but with no pores,[6] nearly straight.[5] Caudal fin round; anal origin under margin of opercle; pelvic fins moderately developed,[6] right pelvic fin continuous with anal fin; [19] dorsal origin on snout tip.[15,19]

Pigmentation: Sides usually dusky with 7–8 black vertical lines, sometimes mottled,[5,6] fins with pale and dark streaks or spots,[6] the spots being more usual in juveniles and streaks in adults; [14] blind side white or with some brownish pigment and variously spotted with black; [6] capable of changing coloration somewhat, those on mud are generally darker and those on sand lighter and with 6 spots on side, takes about 5 seconds to noticeable change in pattern, about one hour to reach extreme coloration.[14]

Maximum length: 202 mm.[6]

DISTRIBUTION AND ECOLOGY

Range: Maine [25] to Venezuela and in the northern Gulf of Mexico.[4]

Area distribution: New Jersey; Delaware Bay; [6] Atlantic bays of Delmarva Peninsula; [18] and Chesapeake Bay from Havre de Grace, Maryland south.[6]

Habitat and movements: Adults—shallow waters, over mud,[4,12,13] sand or silt; [14] bays [29] and estuaries; [15,30] inshore in summer, deeper water in winter,[6] found inshore in Georgia estuaries in all months except January; [20] 0 [2,5]–50 ppt salinity,[18] sexually mature individuals not usually in freshwater; [14] 5–35 C; [20] 15 cm [14] to 60 m; [17,30] completely inshore.[19]

Larvae—move into low salinity waters.[1,9]

Juveniles—shore zone; [13] move up streams [1,14] up to 240 km inland,[10] winter over in bays; [12] 0.0–8.9 ppt salinity; 1.1 C [1]–35.1 C.[13]

SPAWNING

Location: Takes place primarily in estuaries [1,7,10,14] but eggs may be carried as much as 11.1 km offshore.[10,24]

Season: April to October [14] or as early as January,[23] small juveniles every month but May; [27] in Florida appear to be year round in northern Gulf of Mexico; [24] May [1] to September in Chesapeake Bay,[1,9] June to September in North Carolina.[26]

Time: Spawning in evening,[8] 1800–2000 hours.[10]

Temperature and salinity: Spawning starts when waters reach 20 C, peaks at 25 C; eggs reported from 0–24 ppt salinity, majority at 10–16 ppt.[1]

Fecundity: At 87 mm SL, 11,075 eggs; 108 mm SL, 23,075 eggs; [14] 165 mm, 54,000 eggs.[6,19]

EGGS

Location: Near surface in higher salinities,[9,10] near bottom in lower salinities.[1]

Preserved unfertilized eggs: Elongate ovoids, generally with 2–8 flattened depressions,[14] averaging around .5 mm.[6,14]

Unfertilized eggs: .66–.84 mm with an average of .73 mm.[10]

Fertilized eggs: Spherical [10] or ovoid; [1] yellowish, greenish or uncolored (WW); ranging from .67 [10] mm to .86–.84 or 1.22–1.05 mm, salinity dependent, being smaller at higher salinities,[1] .80–.88 mm in Cape Fear River at 25–30 ppt (WW); yolk yellowish or greenish, oil droplets up to 0.06 or .02–.10 mm in Cape Fear River eggs (WW), 15–34 in number,[10] 20–50 in Cape Fear River eggs (WW); perivitelline space not noticeable in marine eggs,[10] but present in estuarine eggs.[1]

EGG DEVELOPMENT

At 23–24 C, times presumed:

- 2 to 2 1/2 hours after fertilization—4 cells to many cells.
- 2–3 hours after fertilization—all in advanced cleavage stages.
- 6–8 hours after fertilization—many greenish granules present.
- 13–14 hours after fertilization—embryos well outlined, eyes just becoming visible; greenish gran-

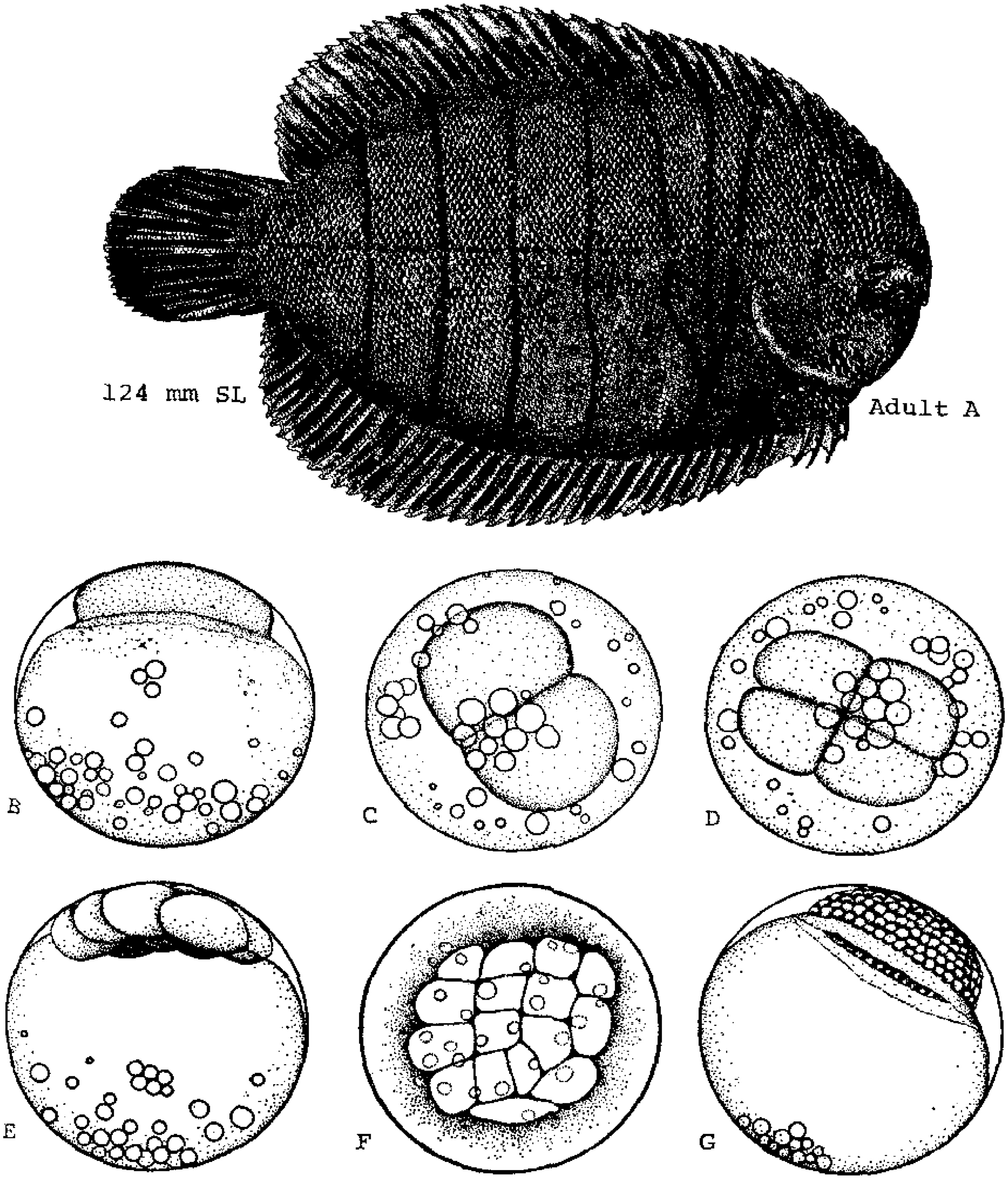

Fig. 107. *Trinectes maculatus,* Hogchoker. A. Adult, 124 mm SL. B. Egg, diameter unstated, very early in development. C. Egg, diameter unstated, two-cell stage, about half an hour after fertilization. D. Egg, diameter unstated, four-cell stage, about 45 minutes after fertilization. E. Egg, diameter unstated, eight-cell stage, about one hour after fertilization. F. Egg, diameter unstated, 16-cell stage. G. Egg, diameter unstated, morula, three or four hours after fertilization. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 948. B-G, Hildebrand, S. F., and L. E. Cable, 1938: figs. 142, 143, 144, 145, 146, 147.*)

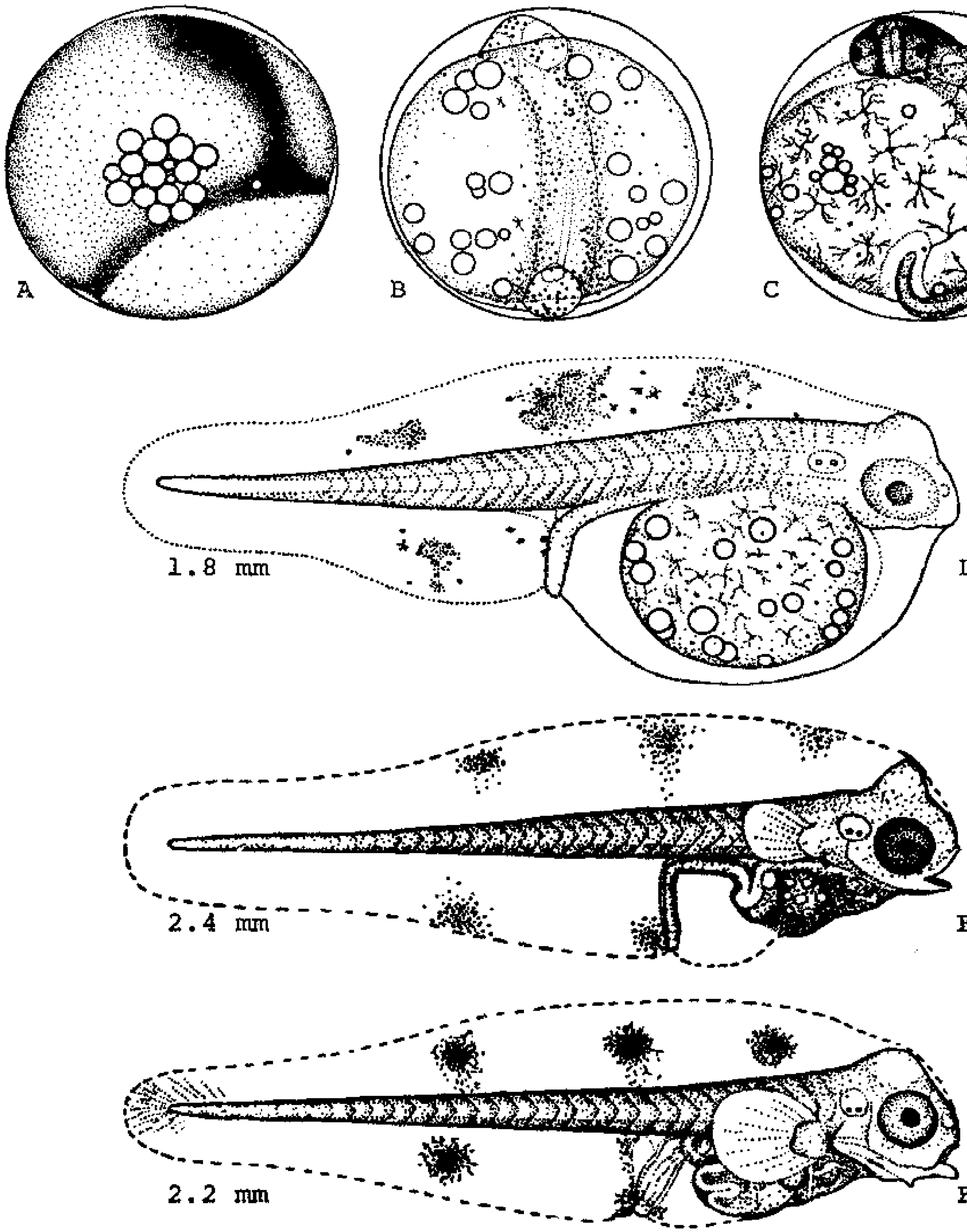

Fig. 108. *Trinectes maculatus*, Hogchoker. A. Egg, diameter unstated, neurulation beginning. B. Egg, diameter unstated, about 12 hours after fertilization. C. Egg, diameter unstated, advanced embryo. D. Yolk-sac larva, 1.8 mm, newly hatched. E. Yolk-sac larva, 2.4 mm, yolk almost absorbed. F. Larva, 2.2 mm, note condensation of pigment blotches. (*A-F, Hildebrand, S. F., and L. E. Cable, 1938; figs. 148, 149, 150, 151, 152, 153. Figs. D, E, and F reversed.*)

ules present on embryo with some scattered on yolk, a few more or less distinct chromatophores visible.

20 hours after fertilization—embryo 2/3 around periphery of egg.

26 hours after fertilization—embryo 3/4 around egg; tail sharply recurved; heart beating slowly; green granules still numerous; many chromatophores present both on embryo and yolk.

36 hours after fertilization—hatching complete.

During early cleavages cell sizes vary considerably, blastoderm flat; during later cleavages blastoderm dome-shaped with a cavity beneath it.[10]

Incubation period: 26–36 hours at 23–24 C.[10]

YOLK-SAC LARVAE

Hatch at 1.7–1.9 mm; yolk sac still retained at 2.2–2.4 mm (16 hours after hatching).[10]

Swim or float initially on back; tail straight and pointed; at hatching head deflected with a prominent hump, finfold wide at hatching; anus about at mid-body; yolk mass large at hatching, very small at 2.2–2.4 mm, with oil globules retained; at 2.2–2.4 mm head no longer deflected, hump more prominent, mouth open.[10]

Pigmentation: Green specks on yolk sac and body except distal part of tail; on finfolds green specks concentrated to form blotches which are somewhat variable in size,

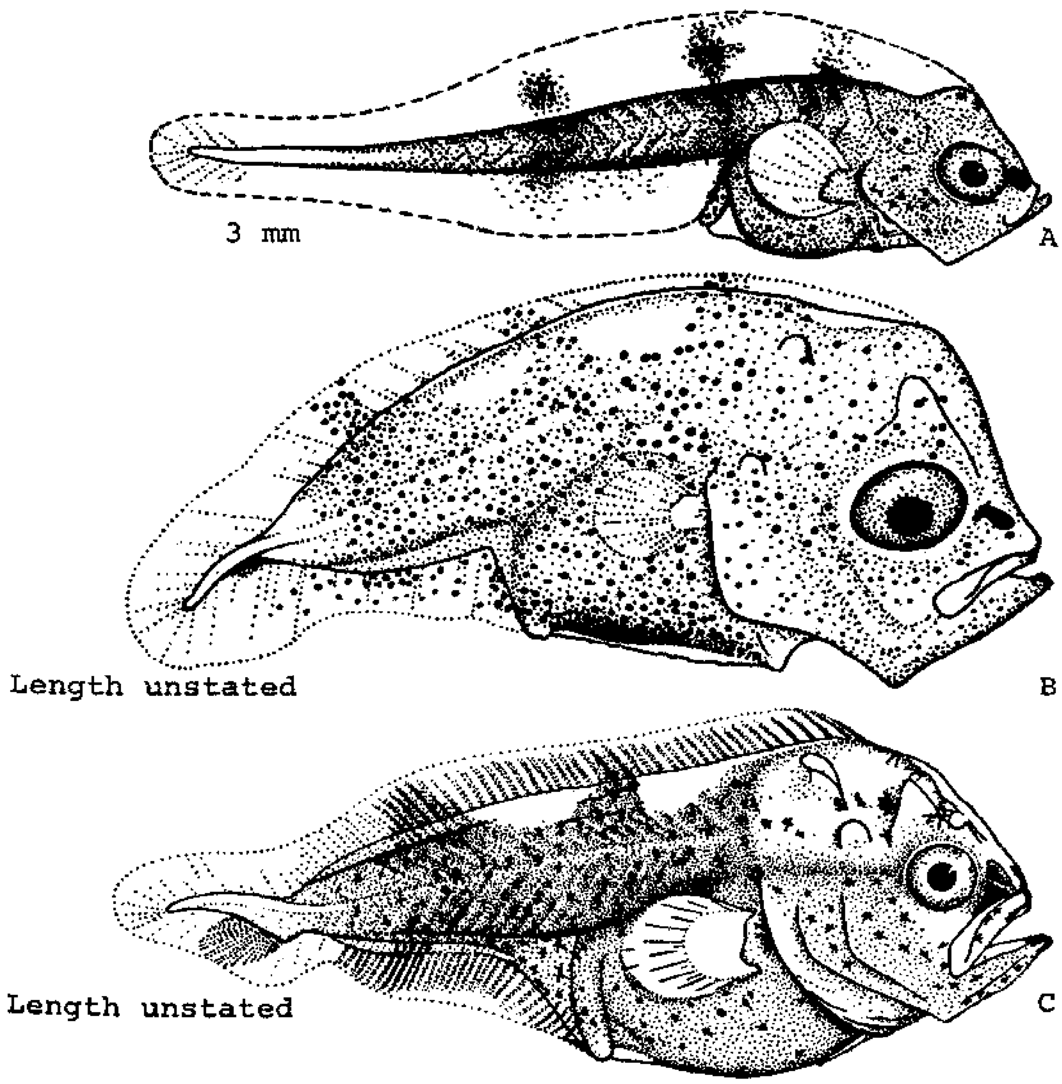

Fig. 109. *Trinectes maculatus*, Hogchoker. A. Larva, 3 mm, 7 days old, melanophores proliferating on body. B. Larva, length unstated, 14 days old. C. Larva, length unstated, 17 days old, flexion of notochord occurring. (A-C, *Hildebrand, S. F., and L. E. Cable, 1938: figs. 143, 155, 156. figs. A and C reversed.*)

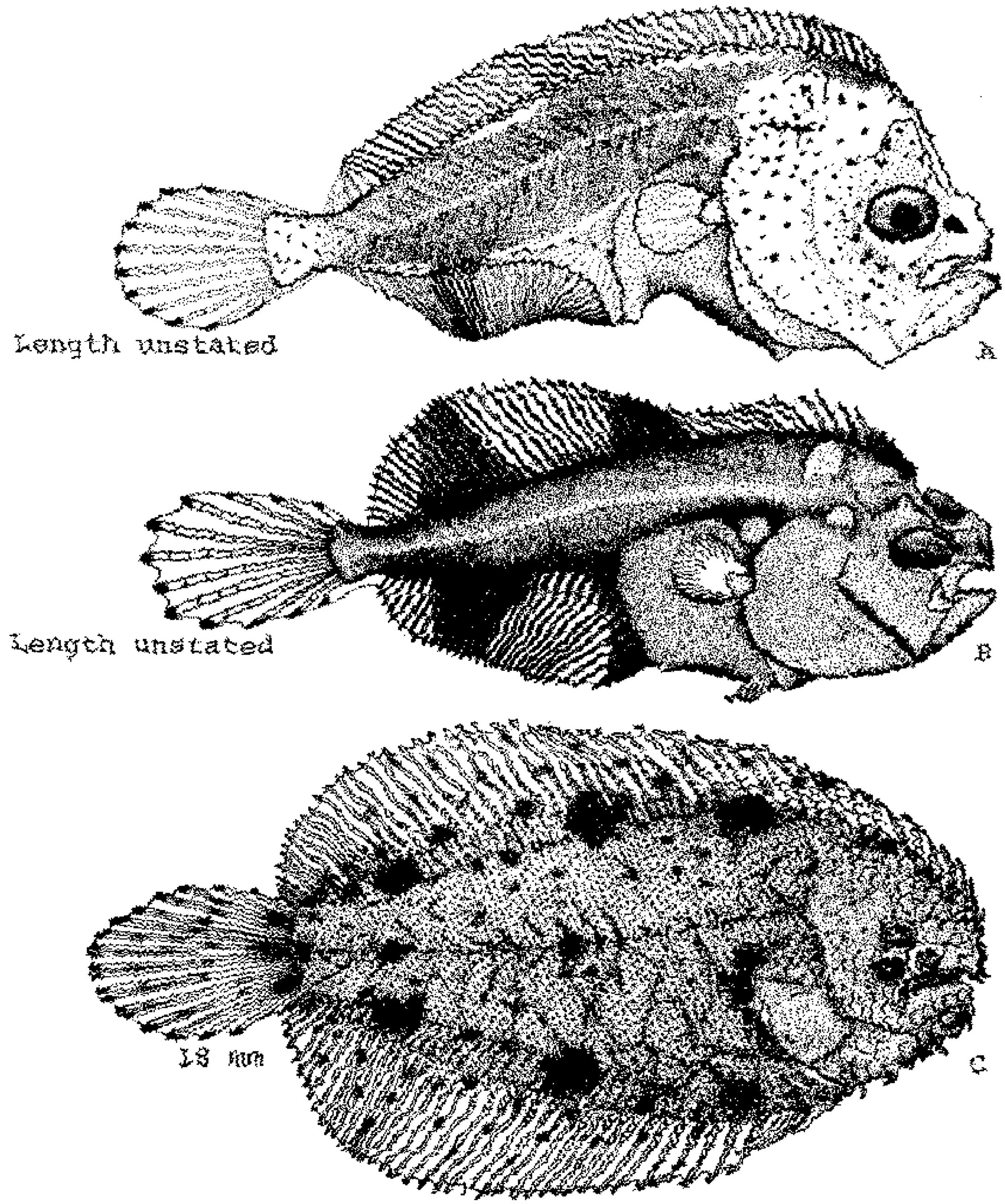

Fig. 110. *Trinectes maculatus*, Hogchoker. A. Larva, length unstated, 32 days old. B. Larva, length unstated, eye migrating. C. Juvenile, 18 mm, adult color pattern still not obtained, scale formation on head still incomplete. *(A-C, Hildebrand, S. F., and L. E. Cable, 1938: figs. 157, 158, 159.)*

density and position; usually one in finfold over yolk sac, one in fold over vent, generally with a corresponding anal blotch just behind vent and another dorsal and ventral pair at about mid-caudal length. In addition to green specks, there are more or less definite melanophores variously distributed on body and finfold.[10]

LARVAE

Yolk absorbed by 2.18 mm (48 hours after hatching), eye migrating by 5.0 mm (34 days after hatching).[10]

Body slender at yolk absorption, becoming deeper at 3.0 mm so that at 14 days, 3.8 mm, body deep and strongly compressed. Hump on head lower at 2.15 mm, head more elongate at 2.5 mm, notch present 3.8 mm (26 days) through which eye will migrate, notch more pronounced at 32 days but eyes still symmetrical; mouth moved forward with jaw slightly projecting at 2.18 mm, lower jaw strongly projecting at 2.5 mm, becoming asymmetrical somewhat like adult at 5 mm (34 days); eye to dorsal ridge at 34 days. Indication of rays in finfold at 3.8 mm (17 days) rays fully developed at 26 days (3.8 mm); pectoral prominent at 3.8 mm; pelvic fins present by 5 mm (34 days); urostyle flexed by 17 days.[10]

Pigmentation: At 2.18 mm color about as in yolk-sac larvae except pigment spots in finfold smaller and more concentrated. At 3.0 mm very definite dark chromatophores on head and abdomen, definite crossbars usually present. Bars on body still present at 14 days but pigment in ventral finfold not concentrated in blotches in the one specimen described, however, a general increase in melanophores. Pigmentation similar on both sides at 17 days. At 34 days pigment blotches essentially as in early larvae and general pigmentation is well developed on both sides.[10]

JUVENILES

Smallest described specimen 18 mm.[10]

Fully scaled at 18 mm; anal fin and anus are forward at 18 mm, pectoral fin present in part at 18 mm, most lost these by 25–30 mm, however, one at 43 mm still retained a rudiment.[10]

Pigmentation: At 18 mm fully pigmented on right side but still with spots in fins, these lost by about 25 mm, 7–8 crossbars develop later; blind side usually unpigmented at 18 mm, but often dusky or spotty.[10]

GROWTH

In April age class 0 fish 18–100 mm, mode at 55 mm, these being 7–12 months old; age class II mode around 140 mm.[10] In another study, average length of 1 year old fish, 42.7 mm SL; 2 year old fish, 65.6 mm SL; 3 year old fish, 83.8 mm SL; 4 year old fish, 100.2 mm SL; 5 year old fish, 113.5 mm SL; 6 year old fish, 124.4 mm SL; and 7 year old fish, 131 mm SL.[9] One study found maximum feeding rates and growth at 25 C and 30 ppt salinity.[27]

AGE AND SIZE AT MATURITY

May mature as early as 2 years,[1,10,11] but all are mature by 4 years. Smallest gravid female recorded was 47.8 mm SL;[11] mature by 115 mm;[6] 4 year old female ripe at 111–124 mm.[5]

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Symphurus civitatus
Symphurus diomedianus
Symphurus minor
Symphurus plagiusa
Symphurus pusillus

tonguefishes
Cynoglossidae

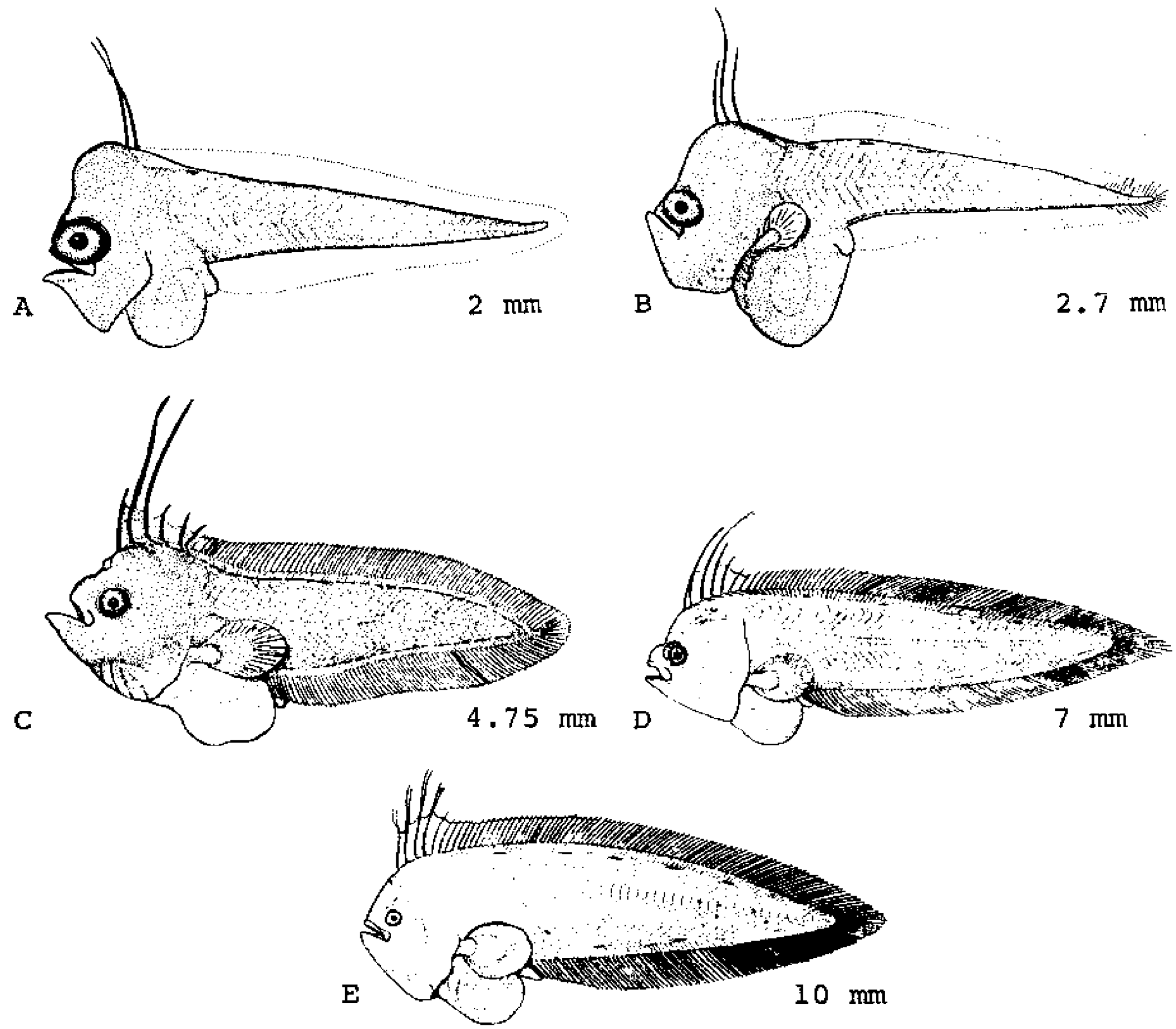

Fig. 111. *Symphurus* sp., Tonguefish. A. Larva, 2 mm. B. Larva, 2.7 mm. Color pattern similar to that shown for *S. plagiusa* by Olney and Grant but gut more loosely coiled. C. Larva, 4.75 mm. D. Larva, 7 mm. E. Larva, 10 mm. Compares very well with 6.2 mm specimen of *S. plagiusa* illustrated by Olney and Grant. (*A-E, Hildebrand, S. F., and L. E. Cable, 1930: figs. 91, 92, 93, 94, 95.*)

FAMILY CYNOGLOSSIDAE

These distinctive flatfishes are primarily of tropical and subtropical distribution. All New World species are small in size. While most common in relatively shallow waters some species occur in quite deep waters on the continental slope.

Hildebrand and Cable, 1930, give an account purported to be for *Symphurus plagiusa* from the area of Beaufort, North Carolina; however, data presented by Olney and Grant (1976) indicate that Hildebrand and Cable may have erred in identifying their material as *S. plagiusa*. The drawings published by Hildebrand and Cable are presented here (fig. 111) because of their historical interest and because they are among the few published drawings of *Symphurus* larvae. In addition to Olney and Grant's data, vertebral counts indicate that there may be three or more species confused, any of which may occur in this region.

Olney (personal communication) states that *S. pterospilotus* and *S. marginata* occur in this region but this information came too late for inclusion of these species in the present volume.

Symphurus civitatus Ginsburg, Offshore tonguefish

ADULTS

D. 87–92; A. 70–77; C. 11–12,[3] 6 + 6;[2] scales 70–79.[3]

Body proportions as percent SL: Depth 30–34; head length 19.5–21.0; preanal length 24–26.[3]

Gape to under posterior margin of lower pupil. Teeth extending over anterior half of upper jaw or less, none on lower jaw.[3]

Pigmentation: Crossbands usually absent or faint, sometimes fairly well marked, no black spot on opercle, occasionally with a dusky area; caudal and posterior part of dorsal and anal variable dusky, sometimes nearly black.[3]

Maximum length: 152 mm.[1]

DISTRIBUTION AND ECOLOGY

Range: Cape Hatteras, North Carolina to Port Aransas, Texas.[3]

Area distribution: Due to the effects of the Gulf Stream, larvae may stray into our area.[1]

Habitat and movements: Adults—11–46 m depth.[4]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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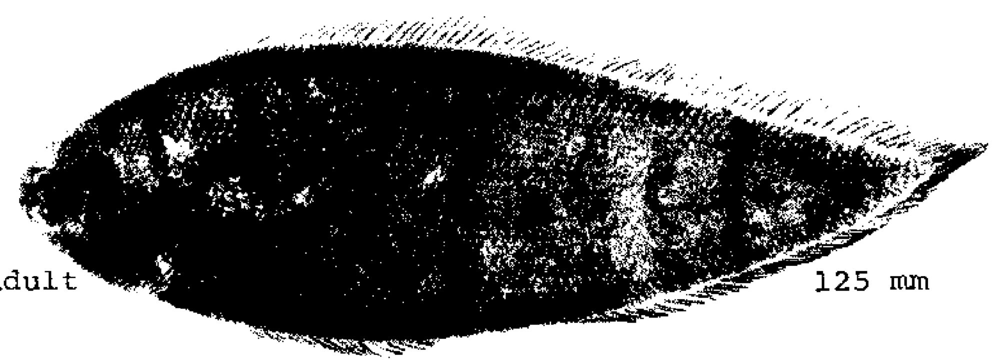

Fig. 112. *Symphurus civitatus*, Offshore tonguefish. A. Adult, 125 mm. (*A, Ginsburg, I., 1951: fig. I.*)

Symphurus diomedianus (Goode and Bean), Spottedfin tonguefish

ADULTS

D. 89–93; A. 73–78; C. 10–11,[6] 5+5–6;[4] scales 85–97.[5]

Body proportions as percent SL: Depth 28.5–31.0; head length 18–20; preanal length 23–26.[5]

Teeth absent in upper jaw on eyed side except occasionally a few at the symphysis, also a few on the middle of the lower jaw.[5]

Pigmentation: Almost uniform brownish or with faint traces of crossbands or irregularly mottled or blotched with dark shades; posterior part of dorsal and anal fins variably dusky, sometimes nearly black with 1–4 rounded irregularly spaced spots on each fin not far from caudal fin on about posterior fifth of SL, the spots moderately or strongly marked, sometimes faint or hardly perceptible.[5]

DISTRIBUTION AND ECOLOGY

Range: North Carolina to Brazil including Gulf of Mexico.[3]

Area distribution: Off Virginia (JEO); due to effects of the Gulf Stream, larvae may stray into the area.[1]

Habitat and movements: Adults—probably prefer hard bottoms,[3] marine salinities;[2] 15[6] to between 146 and 183 m,[7] in 122–260 m off Virginia (JEO).

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

LITERATURE CITED

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Fig. 113. *Symphurus diomedianus*, Spottedfin tonguefish. A. Adult, 152 mm. (*A, Ginsburg, I., 1951: fig. F.*)

Symphurus minor Ginsburg, Largescale tonguefish

ADULTS

D. 72[2]–76;[1] A. 56–61; C. 10–11,[2] 5+5–6;[1] scales 55–56;[2] vertebrae 9+34=43.[1]

Body proportions as percent SL: Depth 28.5–30.5; head length 22.5–24.5; preanal length 27–30.[2]

Teeth on eyed side extend over anterior half of upper jaw.[2]

Pigmentation: In preservation, irregularly shaded or diffusely spotted all over without distinctive markings, may have suggestion of crossbands on posterior part of body.[2]

DISTRIBUTION AND ECOLOGY

Range: Halifax, Nova Scotia to southern Florida.[2]

Area distribution: Not definitely reported for this area, included because its larvae may stray into the area (FDM).

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

LITERATURE CITED

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A Adult

42 mm

Fig. 114. *Symphurus minor*, Largescale tonguefish. A. Adult, 42 mm. (*A, Ginsburg, I., 1951: fig. A.*)

Symphurus plagiusa (Linnaeus), Blackcheek tonguefish

ADULTS

D. 85–92; A. 69–78; C. 9–11 [20] or 10, 5+5; [19] scales 70–85; [20] vertebrae 46–48, 9+37–39.[19]

Body proportions as percent SL: Depth 29.5–31.5; head length 18.5–20.5; preanal length 24–26.[20]

Body elongate, dorsal and ventral outlines about equally convex; head short with snout blunt; mouth small, twisted toward blind side. Teeth minute, in villiform bands,[3] present in anterior half or upper jaw, usually no teeth on eyed side of lower jaw, sometimes a very few teeth at its side.[20] Scales small, ctenoid. Lateral line wanting. Vertical fins confluent, dorsal origin slightly in advance of upper eye, anal fin origin slightly posterior to gill opening; single pelvic fin; pectoral fins wanting.[3]

Pigmentation: Variable; crossbars darker than ground color, present or absent; sometimes with intensely dark, very small specks; a large black spot on opercle centered on its upper lobe, present in most specimens, usually faint or absent in smaller specimens; sometimes a smaller solid or broken black spot also on lower posterior part of head; dorsal, anal, and caudal fins faintly or moderately dusky, usually with a darker pigment along the rays.[20]

Maximum length: To 200 mm.[22]

DISTRIBUTION AND ECOLOGY

Range: New York to the Bahamas and the Greater Antilles, in the Gulf of Mexico from Florida to the Laguna Madre of Texas and the Yucatan Shelf.[6]

Area distribution: Delaware Bay; [13] throughout the Chesapeake Bight; [4] Chesapeake Bay south of North Point, Maryland.[3]

Habitat and movements: Adults—estuaries,[22] bays,[17] channels and deeper flats [10] over mud,[6,10,18,24] sand [18,24] or sparse vegetation; [10] movements probably not extensive; [17] in Gulf of Mexico, inshore throughout the year [1,2] though there may be some offshore movement in the winter; [15] 0 [6,14]–42.9 ppt salinity,[6,8] most common above 29 ppt,[11] in Texas not tolerating above 35 ppt; [7] 5.0 [6,8]–34.1 C; [6,13] shore to 92 m,[6,11] in Florida 97% were caught in less than 14 m [8] while in Texas 80% were caught in 11–16 m; [12] an inshore species.[1]

Larvae—mostly near the bottom; [5] 11–22 ppt salinity.[21]

Juveniles—bottom; [5] a 10.3 mm juvenile taken at surface in evening over 10 m depth (JEO); 5 [16]–22 ppt salinity.[21]

SPAWNING

Location: Probably occurs at sea,[5] however; spawning in large estuaries (such as Chesapeake Bay) is significant.[23]

Season: In Florida, March [6,18] to September,[18] in North Carolina, late May to October with a peak in June,[6] in Chesapeake Bay [23] and Delaware Bay, June, July and August,[13] this temporal pattern indicating temperature dependence (FDM).

EGGS

Ovarian eggs round, largest measured 0.5 mm.[5] Tentatively identified fertile eggs about 0.6 mm with 6–10 oil droplets (JEO).

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

From 1.3 mm NL to at least 10 mm.

Vertebral count at 7 mm given as 9+34–38 [5] (this count indicates a mixture of species present in the sample, perhaps *S. minor*, *S. civitatum* and *S. plagiusa*, FDM); 9+37–39 myomeres at 6.2 mm NL; notochord flexion at 8.2–8.5 mm SL. Head deep with cerebral hemispheres visible at 1.3–1.8 mm NL; forehead sloping; angle of jaw sharp; eye roughly spherical. A single coil in alimentary tract apparent at 1.3 mm NL, continues through development. Body depth increases considerably at 2.4–2.8 mm NL; at 3.7 mm NL maximum body depth occurs at the point of greatest gut protrusion (depth = 34% NL); gut protrusion continues to be a most noticeable feature until metamorphosis. An occipital hump of fleshy tissues on the anterodorsal margin above the pectoral fin bases apparent at 2.2 mm NL, becoming conspicuous by 2.8 mm NL, between 2.8 mm and 3.7 mm NL the hump decreases in height, elongates along its base and gives rise to 2–4 dorsal rays, 2 of which are produced and bifurcated, 2 or 3 produced rays apparent until at least 6.2 mm NL. Anal fin rays beginning differentiation between 3.7 and 4.5 mm NL; caudal fin rays incomplete at 6.2 mm NL; pectoral fin rays small with actinotrichia visible

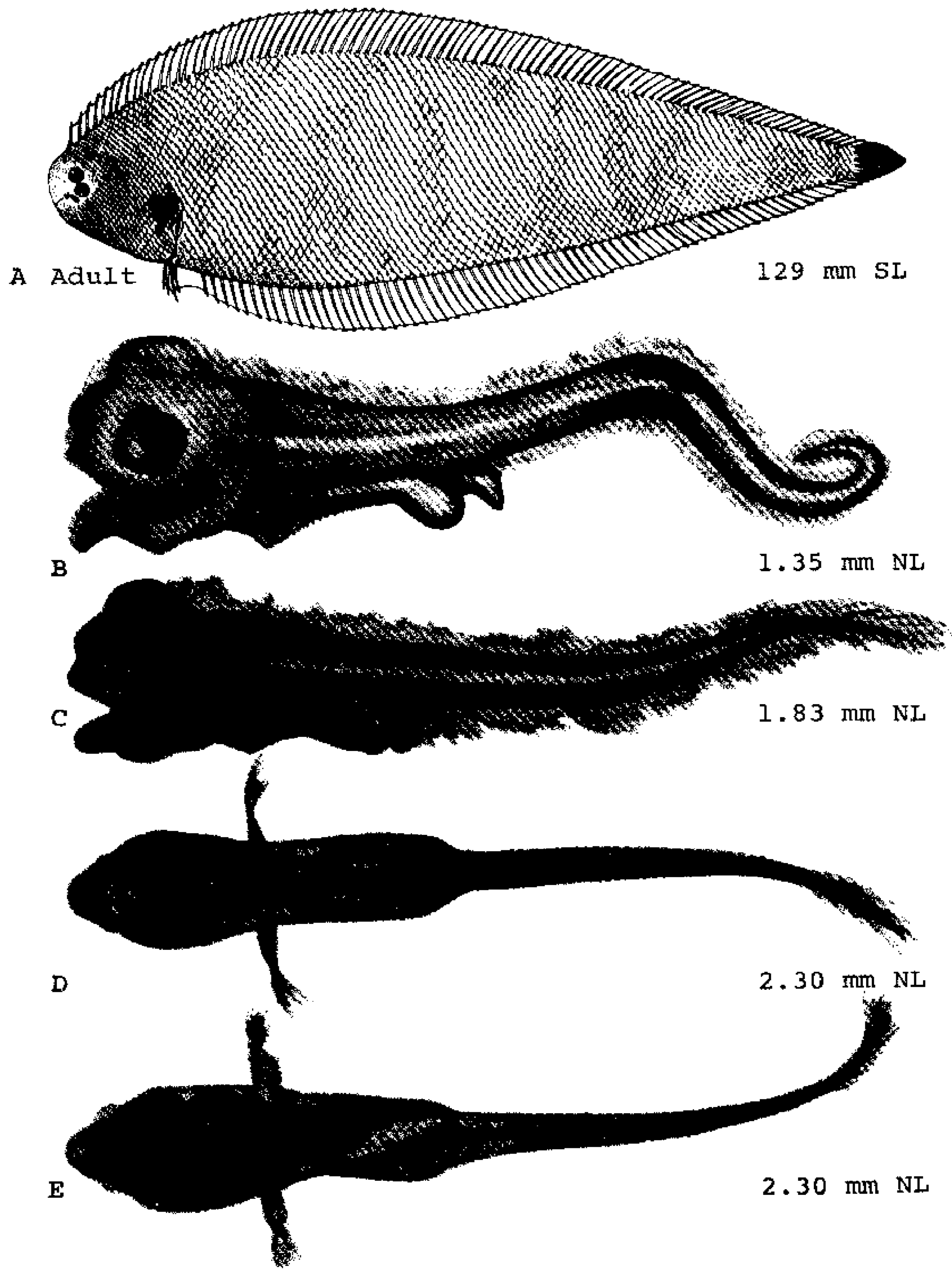

Fig. 115. *Symphurus plagiusa,* Blackcheek tonguefish. A. Adult, 129 mm SL. B. Larva, 1.35 mm NL. C. Larva, 1.83 mm NL. D. Larva, 2.30 mm NL, dorsal view. Note direction of gut coiling. E. Larva, 2.30 mm NL, ventral view. Note scattered pigment on lower side of gut and along mid-ventral region of tail. (*A, Topp, R. W., and F. H. Hoff, 1972: fig. 32. B-E, Olney, J. E., and G. C. Grant, 1976: fig. 2.*)

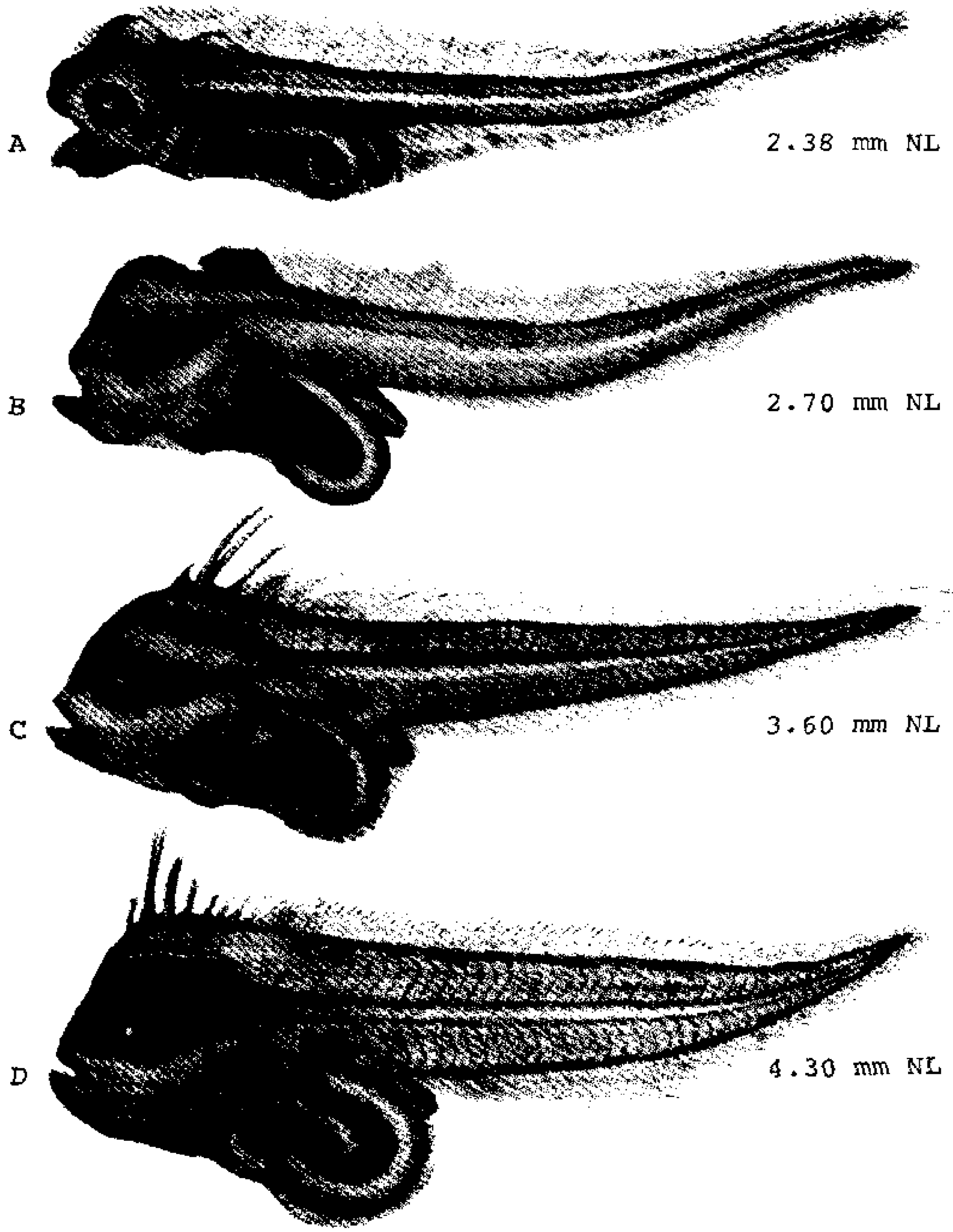

Fig. 116. *Symphurus plagiusa*, Blackcheek tonguefish. A. Larva, 2.38 mm NL. B. Larva, 2.70 mm NL. Gut coil loosening. C. Larva, 3.60 mm NL. Dorsal filaments well-developed. D. Larva, 4.30 mm NL. (*A-D, Olney, J. E., and G. C. Grant, 1976: figs. 2, 3.*)

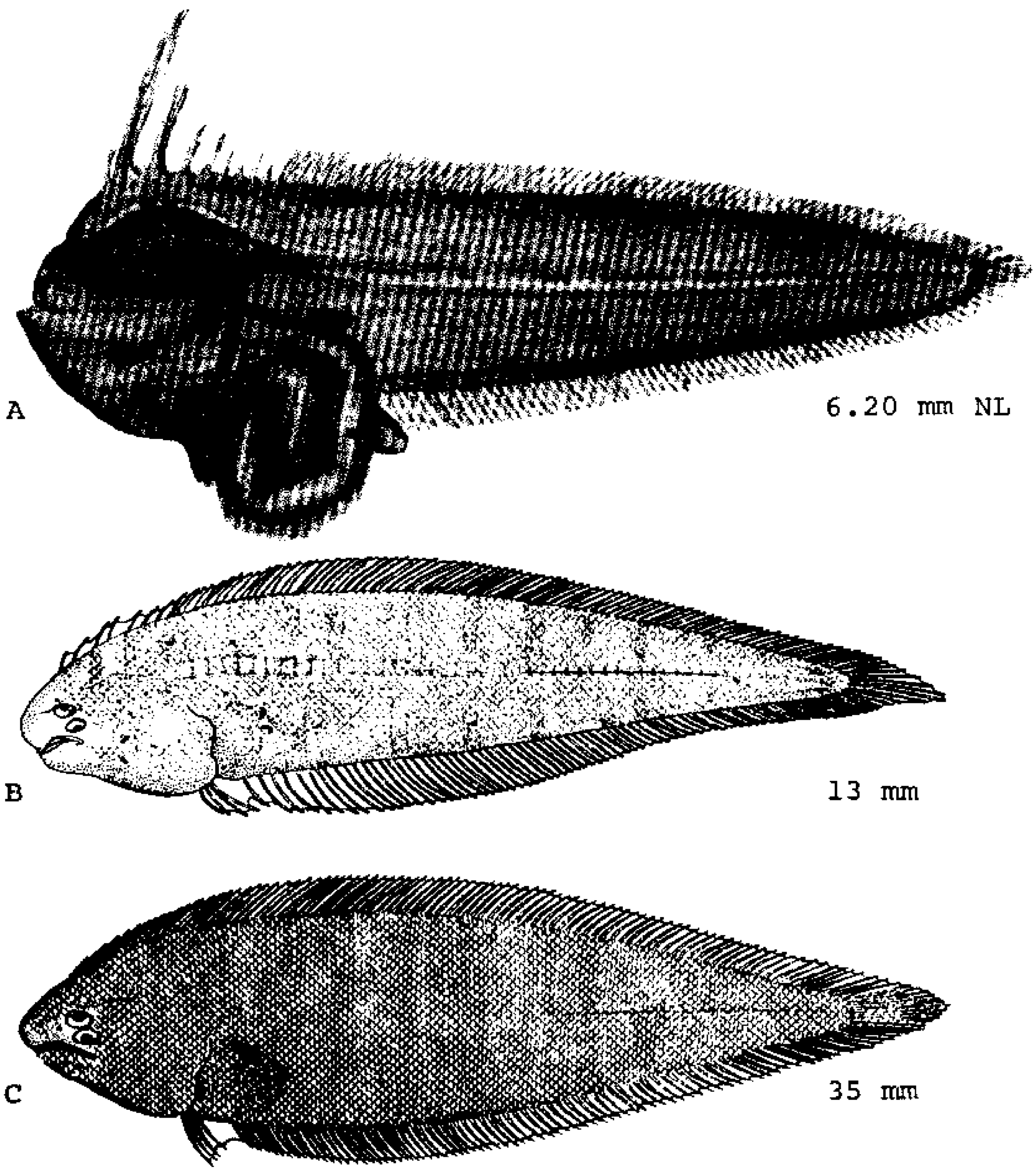

Fig. 117. *Symphurus plagiusa*, Blackcheek tonguefish. A. Larva, 6.20 mm NL. B. Juvenile, 13 mm. Anteriormost dorsal rays still showing evidence of having been dorsal filaments. C. Juveniles, 35 mm. (*A, Olney, J. E., and G. C. Grant, 1976: fig. 3. B-C, Hildebrand, S. F., and L. E. Cable, 1930: figs. 96, 97.*)

at 1.3 mm NL, increasing in size with length, becoming large lobate flaps by 6.2 mm NL, apparently undergoing reduction just prior to metamorphosis; eyes not migrating by 8.5 mm SL.[23]

Pigmentation: 1.3–2.2 mm NL—scattered melanophores ventrally on gut; postanal pigment band 1/2–2/3 distance from vent to notochord tip; dorsally pigment occurs in three concentrations.[23]

2.2–2.8 mm NL—abdominal pigment increases; dark internal pigment under bases of pectoral fins; one large internal pigment spot over air bladder; scattered ventral pigment grades into a distinct double row of small melanophores extending to notochord tip; dorsal pigment increases to 5 chromatophore groupings.[23]

3.7 mm NL—ventral double row of chromatophores merges into two solid lines; additional pigment dorsally.[23]

3.7–4.5 mm NL—dorsal pigment grades into two dark lines, one on either side of dorsal fin; postanal band still apparent.[23]

6.2 mm NL—median line of internal pigment dorsal to vertebral column; internal melanophores on brain; additional ventral pigment line along bases of anal fin rays (JEO).[23]

JUVENILES

From at least 10.3 mm SL (JEO).

At 35 mm depth 28.6% TL; pectoral fin rudimentary at 13 mm; abdomen no longer protruberant at 13 mm.[5]

GROWTH

34–68 mm in 6 to 9 months.[5]

AGE AND SIZE AT MATURITY

No information.

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Symphurus pusillus (Goode and Bean), Northern tonguefish

ADULTS

D. 85–88 [4] or 95–99; [3] A. 71–75 [4] or 83–85; [3] C. 12,[3,4] 6+6; [3] scales 79–82.[4]

Body proportions as percent SL: Depth 28.0–28.5; head length 20.5–22.0; preanal length 27–28.[4] Teeth well developed, extending continuously over anterior half and further back on upper jaw.[4]

Pigmentation: Color brownish, may have traces of crossbands.[4]

DISTRIBUTION AND ECOLOGY

Range: New York and Gulf of Mexico,[2] distribution discontinuous [1] or at least no published records from between these points (FDM).

Area distribution: Not definitely reported for this area; Smith, Sibunka and Wells list it as a possible species contributing to the larvae caught in the area.[2]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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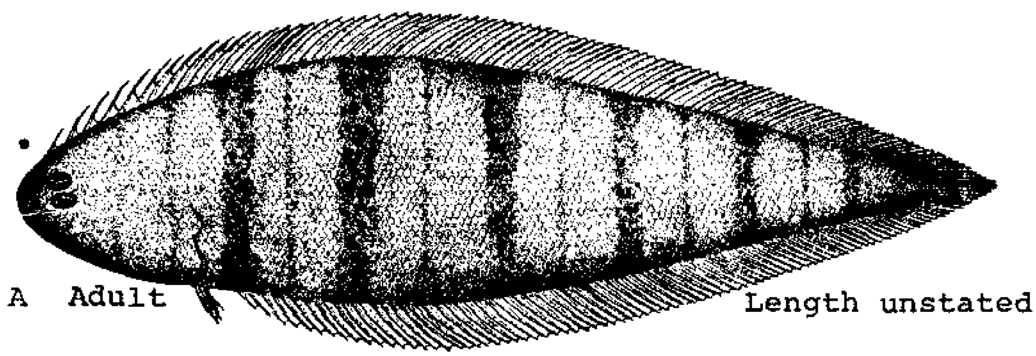

Fig. 118. *Symphurus pusillus,* Northern tonguefish. A. Adult, length unstated. (*A, Goode, G. B., and T. H. Bean, 1895: fig. 379.*)

Echeneis naucrates
Echeneis neucratoides
Remora australis
Remora osteochir
Remora remora
Remorina albescens

remoras
Echeneididae

FAMILY ECHENEIDIDAE

These mostly tropical and warm temperate pelagic fishes are unique in that the spinous dorsal has been modified into a cephalic sucking disc. This disc serves to attach them to host fishes, turtles or other objects, so that if an oceanic species attaches to a host which approaches land, they too become included in the nearshore fauna. The relationship between remoras and their hosts is one of cleaner fish, scavenger or simple hitchhiker, but for some species it may be a combination of all three. Inshore species are not extremely host-specific, but oceanic species tend to be more host-specific with few specimens taken swimming free of their hosts.

An ancestral relationship to the cobias is often postulated. However, this theory is in contest and the evidence is being weighed.

Echeneis naucrates Linnaeus, Sharksucker

ADULTS

D. XXI to XXIX (lamellae) [26]—33–45, modally XXIII, 39; A. 31–41; modally 36; [17] C. 37–40, 10–11+9+8+10–12; [25] P. 20 [7,16]–26; [16] V. 5; [7] branchiostegal rays 9; [26] vertebrae 29 [7] or 30,[4,20,25,26,30] 12+17 [16] or 14+16; [4,25] gill rakers 11–16 on lower limb.[20]

Body proportions as percent HL or SL: Head length 17.5 [26]–20.2 SL; [1] body depth 7.7 [16]–11.0 SL; [1] disc length 10.2–11.6 SL; preanal fin length 49.1–49.7 SL; [26] eye 14.5–16.7 HL [7] or 2.5–3.0 SL.[1]

Body elongate,[2,16] almost round in cross-section; [15] head depressed above,[18] a triangular pyramid with adhesive disc on top; [7] mouth terminal, lower jaw projecting markedly; [2] gape to anterior nostril.[6,18] Gill rakers short and slender, about equal to pupil.[6] Teeth all very small,[26] upper jaw with 3–4 rows of teeth, lower jaw with 7 rows,[7] patches of crowded, very minute, pointed teeth on tongue, vomer, palatines and pharyngeals.[26] Scales cycloid, of two distinct sizes, larger ones narrow, ending in points and arranged in regular imbricated rows, smaller ones truncate behind, less than half the size of the larger ones and arranged in pairs of rows of 3 abreast mainly along edges of larger scales; scales on lateral line long, slender, club-shaped with anterior opening constricted and posterior end of each scale overlying 1/4 to 1/3 of anterior part of following scale.[26] Lateral line indistinct,[7]

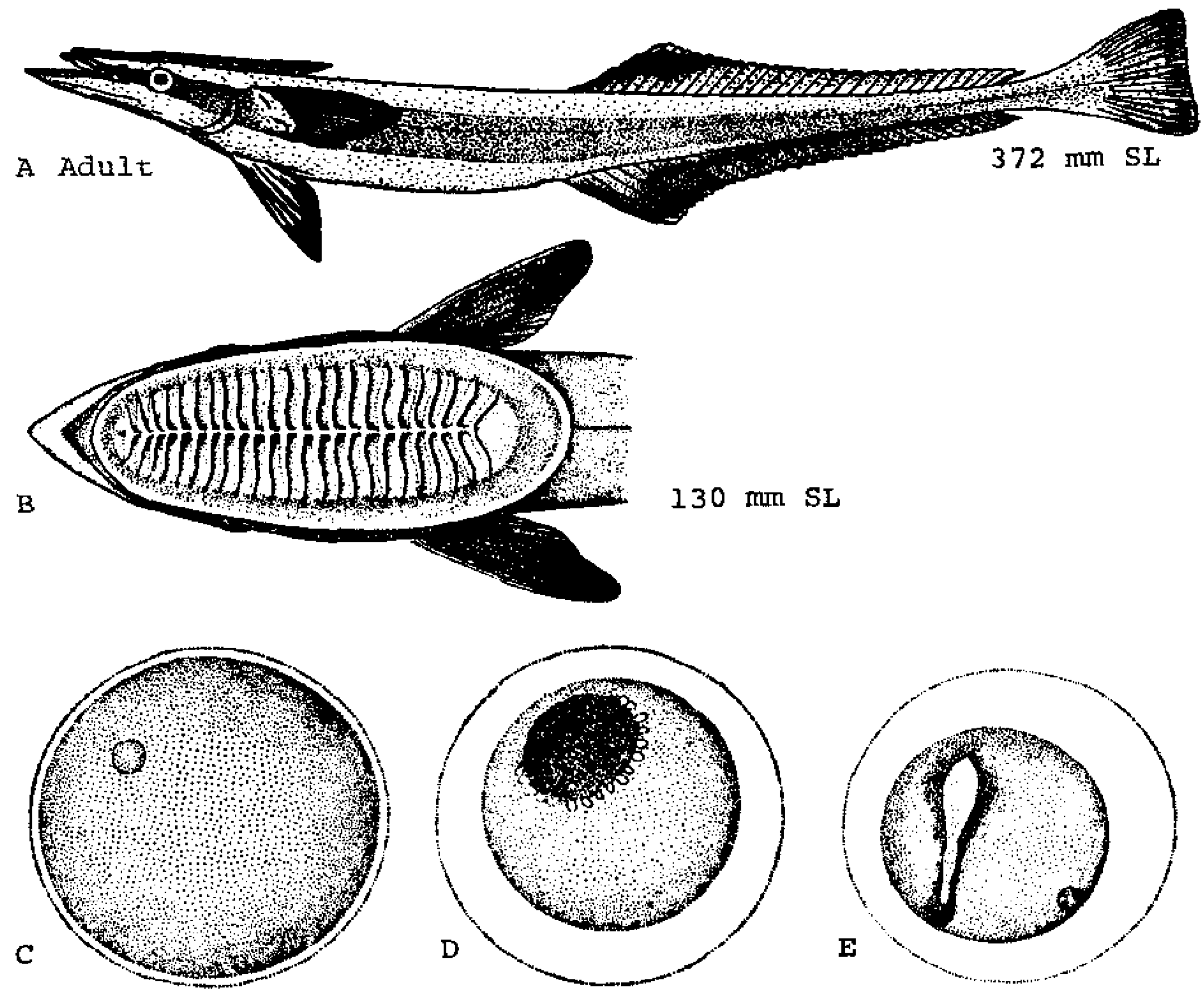

Fig. 119. *Echeneis naucrates*, Sharksucker. A. Adult, 372 mm SL. B. Head of large juvenile, 130 mm SL, dorsal view showing cephalic disc. C. Egg, diameter unstated, shortly after fertilization. D. Egg, diameter unstated, late cleavage stage. E. Egg, diameter unstated, 6 hours after fertilization, neurulation occurring. (*A, Maul, G. E., 1956: fig. 2A. B, Cadenat, J., 1953: fig. 4. C-E, John, C. M., 1950: pl. 7. B, printed reversed.*)

beginning a short distance behind the upper end of the pectoral fin base, beginning descent to mid-lateral position at posterior end of disc; disc long, more or less narrow, reaching posteriorly slightly in advance of pectoral fin mid-length.[26] Soft dorsal fin inserted at about mid-body; caudal fin moderate, rounded in young fish; [2] pectoral fins comparatively large and pointed,[26] tips reaching very slightly beyond tips of pelvic fins; [6] pelvic fins pointed, inserted under rear part of pectoral fin base.[2]

Pigmentation: Sooty [2] or blue-black band in region of lateral line with whitish zones on each side; [7] the dark band going from snout through eye to caudal fin; [13] above and below the whitish zones, ground color dark gray,[1,2] tan, brown, or blackish; [17] belly ivory white; [7] dorsal and anal fins dark brown or gray [1,13] edged with whitish or yellowish; upper and lower lobes of caudal fin also edged in white,[1,2,13,17,26] these edges becoming increasingly restricted with growth; pectoral and pelvic fins blackish.[17]

Maximum length: To about 1000 mm.[2,13,14,18,20]

DISTRIBUTION AND ECOLOGY

Range: Circumtropical; [13,17,20] in western Atlantic from Nova Scotia,[2,15] to Maceio, Brazil, and all of the Gulf of Mexico.[1]

Area distribution: New Jersey; [19,28] Delaware Bay; [22] Atlantic coast of Maryland [21,23] and Virginia; [24] and Chesapeake Bay south of the Bay Bridge.[5]

Habitat and movements: Adults—pelagic, attached to sharks or other large fish,[1,13,14,16,20,21] turtles [16,20] or ships; [20] fresh water [9] to 42.9 ppt salinity,[8] 16.9 [10]–35 C; [8] to 55 m; [10] never captured far at sea, almost always inshore (EAL).

Larvae—no information.

Juveniles—attached to sharks and rays.[3]

SPAWNING

Season: Sexually ripe in February.[11]

Notes: Laid in batches, once or twice a day over a prolonged period.[12]

EGGS

Location: Pelagic; [4,12] occur singly.[12]

Translucent ovarian eggs: 4–5 mm in diameter [7] (perhaps an error? FDM).

Ripe ovarian eggs: 2.40–2.55 mm, semitransparent, with 5-16 small oil globules.[29]

Fertilized eggs: Spherical,[11] colorless under reflected light, yellowish under refracted light; [12] about 2.5 mm,[4] 2.4–2.5 mm,[12] 2.45–2.65 mm [27] or 2.5–2.6 mm,[11] chorion about 0.01 mm thick, smooth, transparent, elastic, under high magnification appears reticulated; non-adhesive; [12] yolk colorless,[4] homogeneous; [19] yolk nearly fills the egg; [4,29] oil droplet .16 [4,11,29]–.20 mm,[11,12,29] single; [4] oil droplet bright yellow.[4,27]

EGG DEVELOPMENT

Blastoderm formed by third cleavage, blastoderm at animal pole, subgerminal disc filled with vacuoles.

3 hours after fertilization—past 180 cell stage, blastoderm a prominent plano-convex disc of isodiametric cells arranged in layers, cells in the various layers identical, no segmentation cavity. At completion of segmentation and commencement of gastrulation the blastoderm flattens out and gradually extends meridionally over yolk mass.

6 hours after fertilization—gastrulation nearly complete; embryo spoon-shaped and about 1.3 mm long; neural folds present as two distinct longitudinal folds bounding the primary dorsal groove; no trace of notochord; indications of formation of somites; enlarged cephalic region rises above periblast; surface of egg takes on a corrugated appearance.

12 hours after fertilization—blastopore closed; egg capsule with a rough reticulated surface; embryo extends 135° around yolk mass, clearly defined from periblast; cephalic region prominent and surrounded by a large perivitelline space; neurochord quite distinct, enlarged anteriorly; neural canal clearly visible in brain region and spinal chord, only faintly visible in nape and posterior caudal region; neuropore comparatively wide; optic vesicles visible, each with a clear, narrow, longitudinal tissue inside; notochord visible as a cylindrical rod commencing from middle of first somite and tapering gradually toward posterior region of embryo; 16 somites visible, first largest, diminishing in size posteriorly; Kupffer's vesicle present behind last defined myotome; yellowish brown pigment in periphery formed by a combination of branched xanthophores and simple melanophores.[12]

24 hours after fertilization—embryo reaches about 180° around yolk,[11] separated from periblast, demarcation most distinct in cephalic region; caudal region completely separated from yolk below; Kupffer's vesicle disappeared; oil globule in front of snout between snout and tip of tail; spinal region marked off from encephalon by a slight fold, a well defined oblique cleft in the postoptic region further dividing encephalon into fore-, mid- and hindbrain; forebrain differentiated from midbrain by cruciform fissure; notochord vacuolated, extending from region of midbrain to

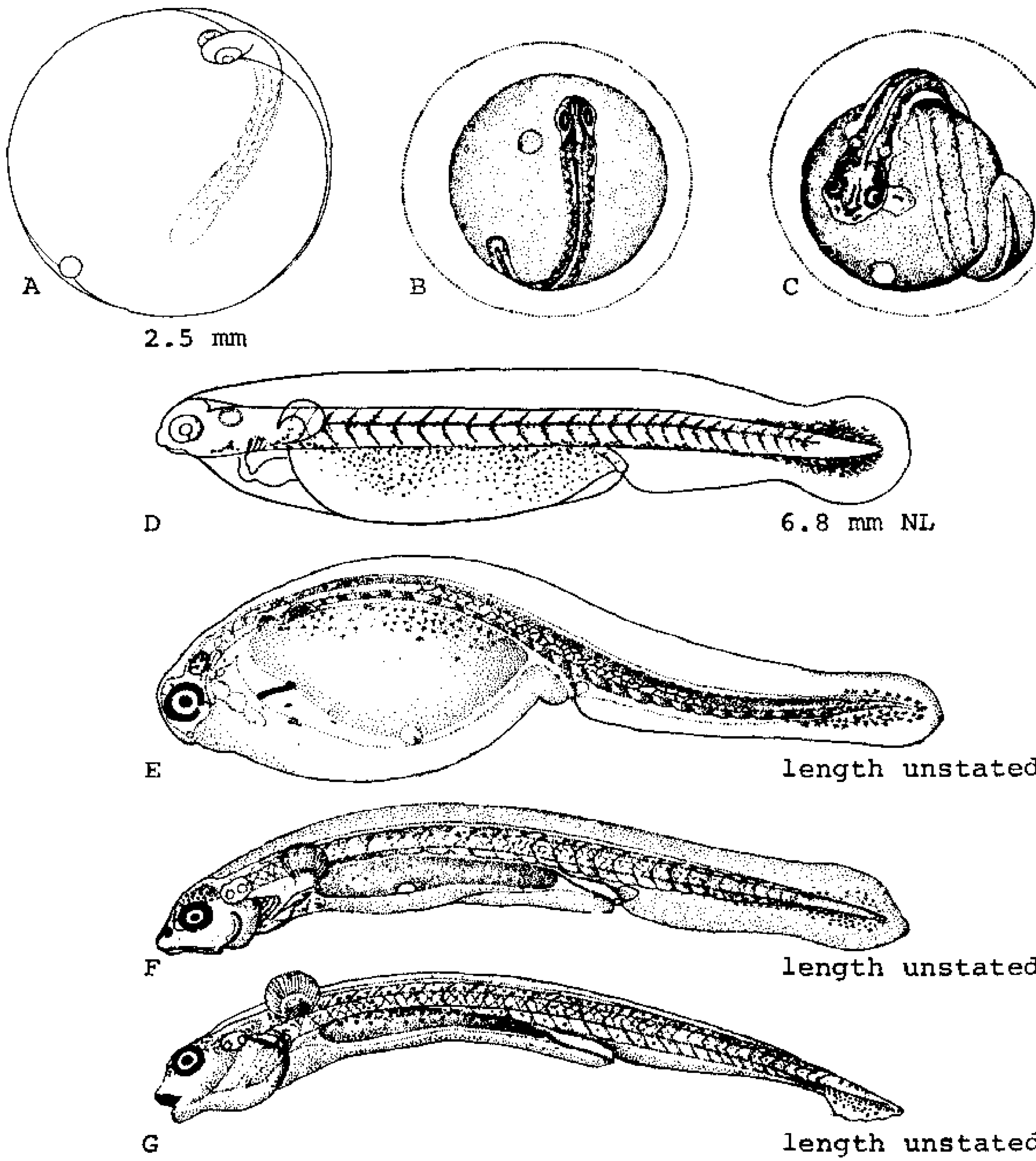

Fig. 120. *Echeneis naucrates*, Sharksucker. A. Egg, 2.5 mm, early stage of development, wild caught egg. B. Egg, diameter unstated, 12 hours old, equivalent stage to fig. A., note difference in perivitelline space. Laboratory spawned fish. C. Egg, diameter unstated, 24 hours old, late developmental stage. D. Embryo, 6.8 mm NL, removed from chorion and straightened, wild caught egg. E. Yolk-sac larva, length unstated, note amount of yolk compared to fig. E., laboratory spawned specimen. F. Yolk-sac larva, length unstated, yolk almost absorbed, 24 hours after hatching. G. Larva, length unstated, 48 hours after hatching. (*A, D, Delsman, H. C., 1931: figs. 10, 11. B, C, E-G, John, C. M., 1950: pl. 7. E-G reversed.*)

tail, projecting slightly beyond last pair of somites; optic vesicle cup-shaped and directed obliquely downwards, choroid fissure very wide; auditory vesicles present as a pair of large spherical chambers in region of hindbrain, inner wall of otocyst thin, two minute otoliths present; olfactory cups near tip of snout; heart a cylindrical tube, auricular portion directed forward, slightly flexed to the right side of embryo between optic and auditory regions,[12] beating; [27] 3 pairs of gill pouches; pectoral fold projecting slightly upward; caudal region clearly defined; yellow pigment increased considerably; also irregular melanophores in periphery.

48 hours after fertilization—embryo reaches completely around yolk; oil globule midway between snout and anterior caudal region; an aggregation of vacuolated yolk granules in front of snout; eyes better defined; choroid fissure narrow; otocysts somewhat elongated; otoliths conspicuous; olfactory sacs larger with thicker walls; 28 somites with indications of 2 more; heart L-shaped, beating 146/min.; embryo yellowish brown with darker tint in region of head and tail where there is a greater concentration of irregular melanophores; stellate xanthophores extending on yolk sac.[12]

72 hours after fertilization—hatching begins; [11,12] yolk sac reduced; more black pigment present; a rhomboidal zone of color near end of tail present.[11,29]

Myotome counts given as 16 + 16 [4] or 16–17 + 14.[27]

YOLK-SAC LARVAE

5.8–9.3 mm.

30 V-shaped myomeres, first just posterior to auditory vesicle,[12] 11 + 16 visible at hatching; head relatively short and broad. Yolk sac reduced at hatching,[11,29] much reduced at 24 hours after hatching, a narrow elliptical sac; oil globule ventral, 24 hours after hatching nearly halfway between mouth and anus. Mouth formed at 24 hours after hatching, lower jaw supported by Meckel's cartilage.[12] Choroid fissure visible but reduced at hatching, only a vestige at 48 hours after hatching; [12] otocysts small at hatching. Pectoral fin very small, rounded and membranous at hatching,[11,29] rays beginnings at 48 hours after hatching, finfold continuous at hatching, comparatively low and narrow. Notochord extending from midbrain into tail, projecting slightly beyond last myomere.[12] Gut relatively long at hatching; [11,29] anus at 16th myomere.[12]

Pigmentation: Pigment absent [11,29] or present at hatching, densely pigmented at 48 hours after hatching. Yolk sac covered with yellowish brown pigment; yellowish brown pigment dense on head but denser in caudal region and less intense over rest of body.[12]

LARVAE

Yolk absorbed by 9.3 mm.

Head a little depressed with a prominent snout, lower jaw protruding. Eye deeply pigmented, no vestige of choroid fissure. Caudal fin rays visible in lower lobe at 9.3 mm; finfold continuous at 9.3 mm. Anus situated on a prominent papilla.[12]

Pigmentation: Greenish brown [12] or yellowish.[11,29]

JUVENILES

Reported from 70 to 178 mm; [3] has a series of small, slender teeth in advance of others; [6] up to 178 mm, caudal fin with elongate middle rays.[3]

GROWTH

No information.

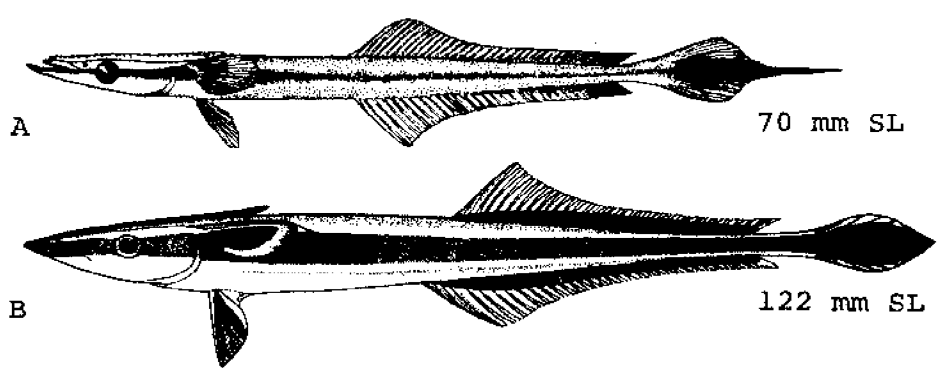

Fig. 121. *Echeneis naucrates*, Sharksucker. A. Juvenile, 70 mm SL, note central elongation of caudal fin. B. Juvenile, 122 mm SL, caudal fin pointed, not truncate as in adult. (*A, Gudger, E. W., 1926: fig. 5. B, Fowler, H. W., 1928: fig. 66.*)

AGE AND SIZE AT MATURITY

All above 410 mm adults.[7]

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Echeneis neucratoides Zuieuw, Whitefin sharksucker

ADULTS

D. XVIII to XXIII, 32–44, modally XXI, 23; A. 30–38, modally 33.[1]

Body proportions as percent TL: Head length 20; body depth 9; disc length 27.[2]

Body stouter than that of *E. naucrates*.[1]

Pigmentation: General body color variable, dark brown or blackish in adults; stripe down the side usually present but sometimes obliterated by ground color; pectoral and pelvic fins dark brown to black; whitish area distally in dorsal and anal fins; upper and lower caudal lobes with white areas, these areas smaller in older adults but always larger than those of *E. naucrates* of similar size.[1]

Maximum length: To between 610 and 915 mm.[1]

DISTRIBUTION AND ECOLOGY

Range: New England to the West Indies and Gulf of Mexico.[1]

Area distribution: New Jersey,[5] Atlantic coast of Maryland, lower Chesapeake Bay.[4]

Habitat and movements: Adults—attach to sharks, sturgeon or free-living; [1] in Rhode Island only in summer and fall; [3] strictly inshore.[1]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Fig. 122. *Echeneis neucratoides*, Whitefish sharksucker. Adult, 330 mm TL. (*Böhlke, J. E., and C. C. G. Chaplin, 1968: 320. © Philadelphia Academy of Natural Sciences, used with permission of authors and publisher.*)

Remora australis (Bennett), Whalesucker

ADULTS

D. XIV to XXVII (lamellae)[1]—23[3]–27,[4] modally XXVI–25;[3] A. 20–26,[4] modally 25; caudal 12–15 + 9 + 8 + 13–15, modally 13 upper and 14 lower procurrent rays;[3] P. 21–24,[3,4] modally 23;[3] V. I, 5,[3,8] spine hidden in skin;[7] vertebrae 27;[4] gill rakers 1–3 + 14–19, modally 2 + 17.[3]

Body proportions as percent TL, SL or HL: Head 28.6 TL; depth 12.7 TL; orbit 10.1 HL;[7] disc 48–52 SL.[3]

Upper jaw subtruncate, overreached by lower jaw; gape to a vertical from the nostril[7] or 3/4 the distance from tip of mandible to orbit.[6] Upper arm gill rakers small, round, lower arm gill rakers long.[3] Teeth in broad villiform bands,[6,7] outer series larger than other teeth;[7] vomerine and palatine teeth also in bands. Scales minute, sitting in minute pits,[6,7] ovoid in shape.[6] Lateral line running high on body parallel to disc to end of pectoral fin, descending to midline of body, running straight to caudal peduncle. Anal fin under and similar to soft dorsal fin; pelvic fins pointed; pectoral fins inserted under opercular margin, rounded; caudal fin truncate.[6]

Pigmentation: Uniform blue,[3,4] light green, violet, brown or black,[4] usually[4] with a white edging on each fin;[3,4] in formalin, slaty blue or brown.[3]

Maximum length: To 760 mm.[4]

DISTRIBUTION AND ECOLOGY

Range: World-wide in warm seas.[3,4,5]

Area distribution: Virginia.[2]

Habitat and movements: Adults—attached to certain marine mammals.[3,4]

Larvae—no information.

Juveniles—attached to porpoises.[1]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

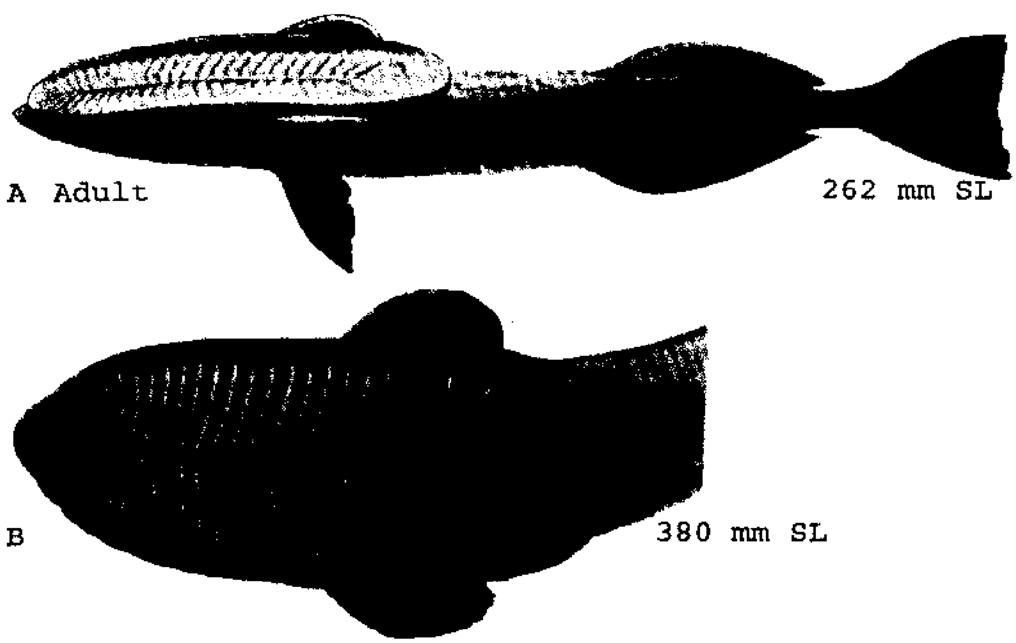

Fig. 123. *Remora australis*, Whalesucker. A. Adult, 262 mm SL. B. Disc of adult 380 mm SL. The number of laminae, shown in this illustration, 28, is the upper extreme number. (*A-B, Follett, W. I., and L. J. Dempster, 1960: pl. 1.*)

LARVAE

No information.

JUVENILES

46 mm specimen reported; 25 lamellae in disc; disc about 50% SL.[1]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Remora osteochir (Cuvier), Marlinsucker

ADULTS

D. XVI to XX (lamellae)—20–27; A. 20–26; P. 20–24;[6] V. 6; branchiostegal rays 8;[11] vertebrae 27.[6,11]

Body proportions as percent SL or TL: Head length 18.7[11]–21.4 SL; disc 44.4 TL[1,8]–46.1 SL; eye 2.6 SL; preanal fin length 58 SL.[11]

Body depressed, thick with a slender caudal peduncle; head small, depressed;[11] mouth very small; gape not reaching eye.[1,8] One row of minute incisors on premaxillary and a narrow band of moderately sturdy teeth, palatines with a broad band of minute teeth and with one row of stronger ones along the outside, continuing along the anterior edge of the vomer, narrow band of teeth along edge of mandible, some outer ones rather large. Scales very small and sparse, scattered with large intervals between them, lateral line scales long, narrowly winged. Lateral line beginning a short distance behind upper end of pectoral fin base, descending to mid-lateral position in a short curve at posterior end of disc.[11] Pectoral fins rounded with rays enlarged and stiffened,[11] crenate borders; soft dorsal and anal fins fairly high, last

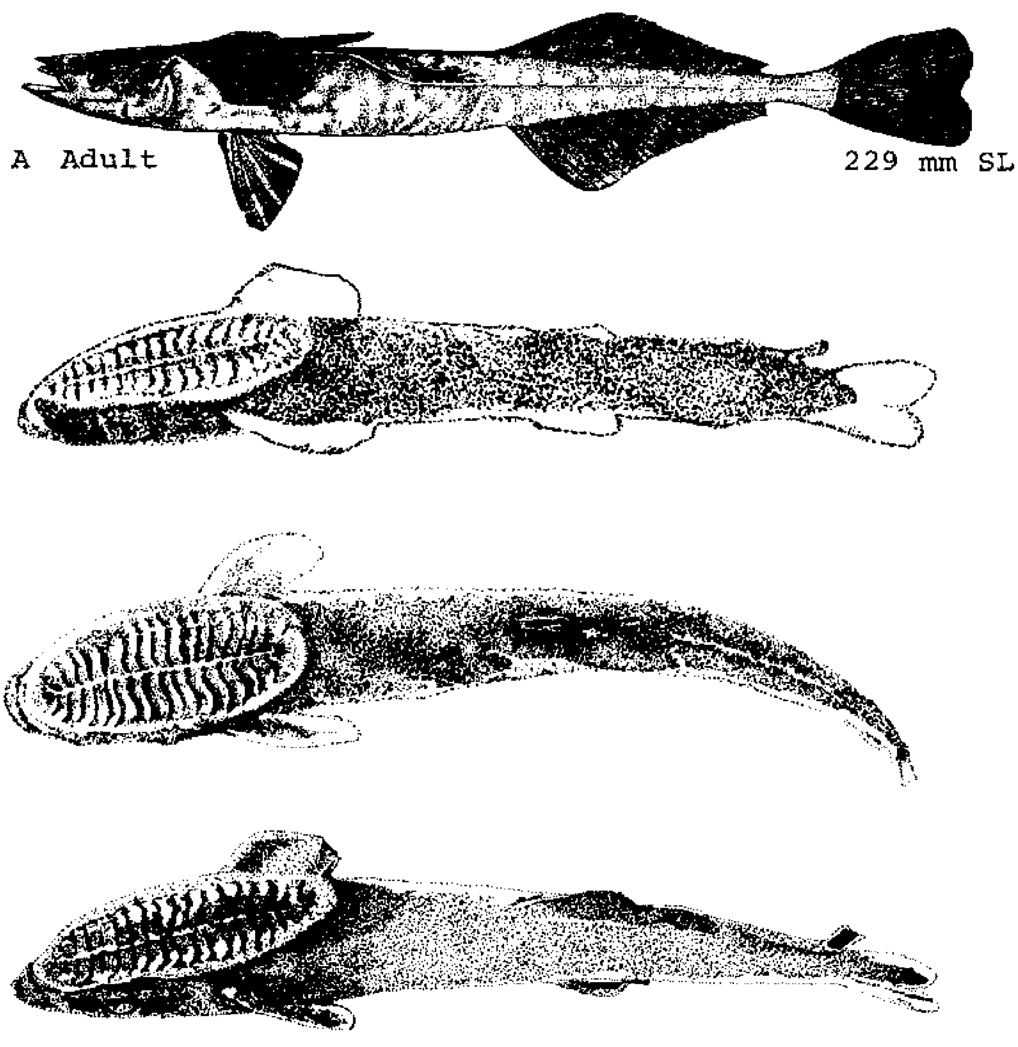

Fig. 124. *Remora osteochir*, Marlinsucker. A. Adult, 229 mm SL. B. Juvenile, 36 mm SL. C. Juvenile, 46 mm SL. D. Juvenile, 55 mm SL, except for stoutness of juveniles, essentially of adult form at all sizes figured. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 798. B-D, Gudger, E. W., 1928: fig. 2, delineated by Tamiko Karr.*)

rays connected to caudal peduncle by a very small membrane; pelvic fins moderately long and pointed; [11] caudal fin rounded [10] or emarginate.[1,8,10]

Pigmentation: Almost uniform gray, violet-gray,[10] tan [4,8,11] or brown; [6] fins and tail blackish, obscure whitish spots on lower lobe of tail,[10] underside of head, ventral line, part of pelvic fins and a spot on pectoral fins pale,[8] iris blackish.[11]

Maximum length: To 406 mm.[10]

DISTRIBUTION AND ECOLOGY

Range: World-wide in warm seas.[6,9]

Area distribution: New Jersey; [5,11] off mouth of Delaware Bay,[7] Atlantic coast of Maryland; [11] and Chesapeake Bay.[8]

Habitat and movements: Adults—free living [6] or attached to billfishes [1,4,6,8] or wahoos,[6] vast majority of museum specimens were taken from billfishes (EAL).

Larvae—no information.

Juveniles—attach to billfishes, sharks and molas.[2]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Reported from 32 [3] to 62 mm SL.[2]

D. XVI to XVII [2,3]–22 soft rays; A. 21; C. 16; P. 19–20; V. 5.[3]

Disc length 34.4 [3]–37% SL [2,3] increasing with size; [3] head length 25–31% SL,[2] decreasing with size; head width 15–20% SL.[3]

Caudal fin deeply emarginate; pectoral fin rounded, broad, with first two rays broad, stiff and strong.[3]

Pigmentation: In formalin, blue-gray all over; dorsal and anal fins blue-black; pectoral fins transparent; pelvic fins transparent at 32 mm SL, black in larger specimens; caudal fin transparent at 32 mm SL; black at 41 mm SL and intensely black at 49 mm SL.[3]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Remora remora (Linnaeus), Remora

ADULTS

D. XVI to XX (lamellae)—21–27;[10,13] A. 20[10]–25;[9,15,21] C. 39–43; 11–13 + 9 + 8 + 11–13;[18] P. 26–30;[13] V. 6; branchiostegal rays 9–10;[21] vertebrae 27, 12 + 15;[18,20] gill rakers 4–6 + 25–28 = 29–34.[13]

Body proportions as percent SL or HL: Depth of body 17 SL;[10] head length 19.7–25.7 SL; eye 2.6–5.0 SL[21] or 18 HL;[1] disc length 28.2–39.3 SL; preanal fin length 49.2–63.3 SL.[21]

Body elongate, rounded in cross-section forward, somewhat compressed posteriorly;[1] head broad, depressed;[20] mouth terminal, lower jaw projecting; gape to under anterior edge of eye.[1] Teeth small, pointed,[1] outer row of premaxillary consisting of about 45 close-set teeth, inside this row a band of wide-set teeth, inner ones largest, lower jaw with a wide band of teeth, outer ones large and inner ones minute, short but robust pointed teeth in bands on palatines and vomer, patch of minute teeth on tongue. Scales very small, cycloid and strongly imbricated; largest non-lateral line scales somewhat smaller than the lateral line scales, smallest non-lateral line scale about half as big as largest; lateral line scales mostly with an interval between them, few overlapping, their oblique anterior and posterior ends constricted so that the diameter of the openings are about half as great as that of the middle tubular part. Lateral line begins above upper end of pectoral fin base and starts sloping down to mid-lateral position 3/4 distance between upper end of pectoral fin base and end of disc, reaching midlateral position at midpoint between end of disc and soft dorsal insertion. Soft dorsal and anal fins low,[21] both inserted at about mid-body,[1] membranes connecting last ray with caudal peduncle very small,[21] caudal fin moderate, lunate; pectoral fins rounded, base below mid-lateral position; pelvic fins triangular, inner ray attached to body for most of length.[1]

Pigmentation: Body nearly uniform tan,[9] brown,[1,4,8,15] gray, grayish white[21] or nearly black.[1,4,10]

Maximum length: Reported to reach 864 mm[13] but few specimens exceed 460 mm.[1,4,9]

DISTRIBUTION AND ECOLOGY

Range: Cosmopolitan in warm seas,[17] in western Atlantic north to New York, straying to St. Pierre Bank, in Canadian waters.[1]

Area distribution: New Jersey;[12] Atlantic coast of Maryland.[16]

Habitat and movements: Adults—pelagic,[8] free living[13] or attached to sharks, turtles or ships,[1,4,13] most frequently attached to pelagic sharks.[10]

Larvae—pelagic,[6] reported from 35.4–35.8 ppt salinity, 24.5 C[7] and 25–50 m depth.[6]

Juveniles—free living[14] or attached to sharks; surface of open ocean.[2]

SPAWNING

Oceanic spawner; based on presence of pelagic larvae, spawning is postulated for May and June[6] or August; eggs collected at 25.6 C.[7] Ripe females found in second half of August and first half of September.[22]

EGGS

Ovarian eggs: 1.40 mm with oil droplet diameter 0.32 mm, chorion reticulated, yolk vesiculated.[22]

Fertilized eggs: Spherical;[22] 2.1–2.2 mm[7] or 1.40–1.52 mm; chorion reticulated; yolk with numerous small granules, these reducing its transparency; oil droplet single, 0.32 mm, yellowish; perivitelline space absent.[22]

EGG DEVELOPMENT

Embryo lies on middle meridian; at time of otic vesicle formation body sparsely spotted with tiny spots of citron yellow, also some black spots; melanophores on oil droplet larger and more stellate than those on body.[22]

YOLK-SAC LARVAE

Hatch at 4.72 mm.

27–28 trunk myomeres; preanal length/postanal length 1.68 at 4.72 mm; yolk mass distinct at hatching; oil droplet in posterior part of yolk sac; pectoral fin small at hatching; large preanal finfold at hatching; gut straight; anus well behind yolk mass.[22]

Pigmentation: Yellow and black pigment present; yellow sparse, in small points on body; black pigment also scattered as points, most melanophores on yolk sac and oil droplet larger and stellate; finfold margin with a sienna margin.[22]

LARVAE

Reported from 4.8[7]–15 mm,[5] may shrink in laboratory down to 3.68 mm.[22]

D. XVIII–25 1/2; A. 22; C. 9 + 8; P. I, 20 at 15 mm; lips reported to have suckers at 15 mm,[5] however, these suckers appear to be empty tooth sockets where deciduous

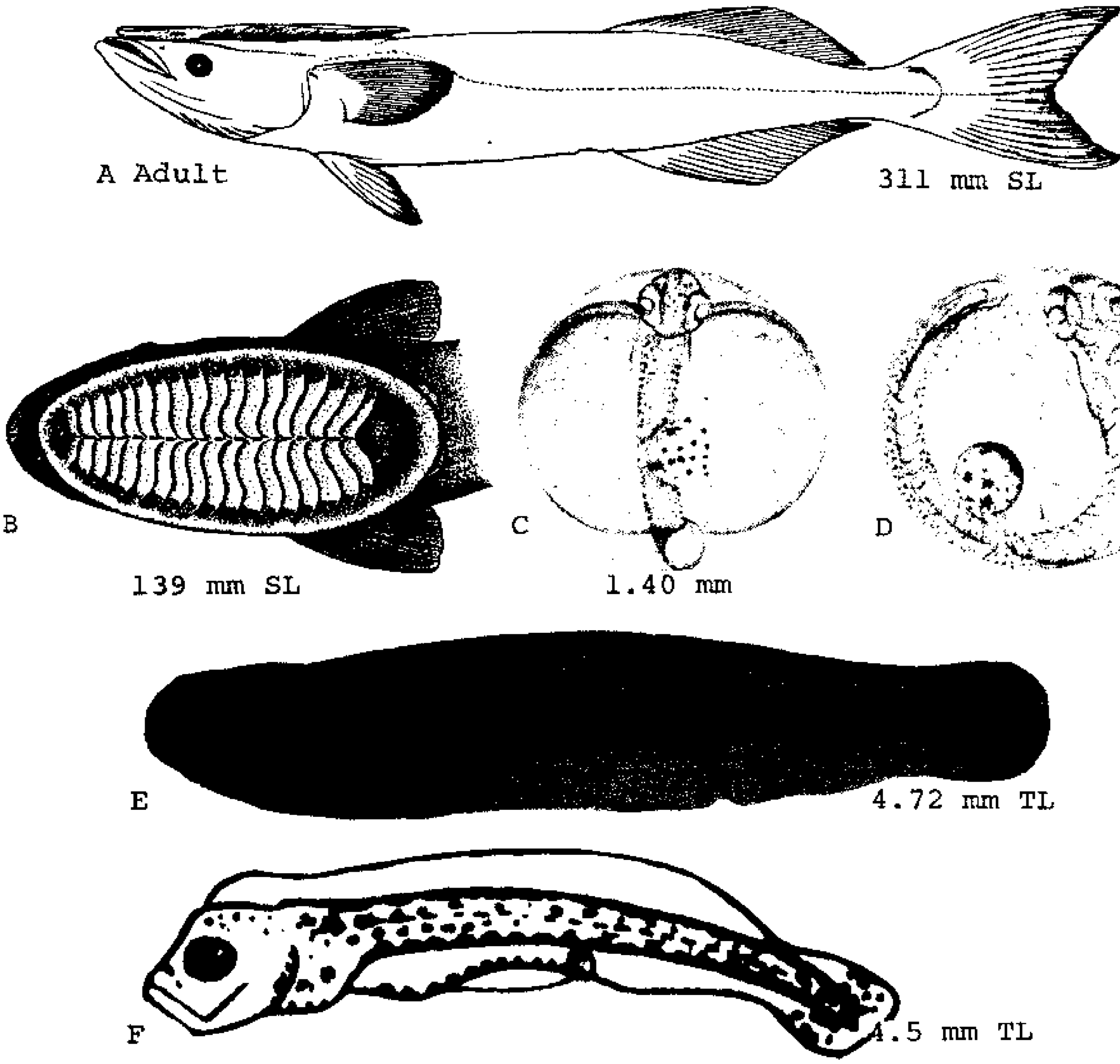

Fig. 125. *Remora remora*, Remora. A. Adult, 311 mm SL. B. Head, dorsal view showing cephalic disc, 139 mm SL. C. Egg, 1.40 mm diameter. D. Egg, same as previous one, less than one day from previous stage. E. Yolk-sac larva, 4.72 mm TL. F. Larva, 4.5 mm TL. *(A, Maul, G. E., 1956: fig. 2b. B, Cadenat, J., 1953: fig. 8. C, D, Sanzo, L., 1928: figs. 1, 2. F, Zhudova, A. M., 1969: fig. 53.)*

teeth had fallen out (EAL).

At 15 mm disc length 25.8% SL, head length 23.2% SL;[5] preanal length greater than postanal.[22]

At 15 mm, in upper jaw, a row of 8 or 9 teeth, lower jaw with a row of 8, on lateral edge of premaxillary an irregular row of short, out-jutting teeth, 10–15 in all, 2 pairs of interlocking fangs.[5] Head dorsal profile concave at 8 days after hatching; mouth open on third day after hatching; Meckel's cartilage formed at opening of mouth.[22] Lateral line visible in stained 15 mm specimen.[5] Below 8 mm TL no trace of cephalic disc, at 10 mm TL slight oblong traces behind the head, at 12 mm TL disc with distinct lamellae and has moved forward; [19] pectoral fin large, rounded at 5 mm, at mid-lateral position on eighth day after hatching.[22] Scales wholly absent at 15 mm.[5] Gut large, anal opening restricted compared to gut.[22]

Pigmentation: Head and trunk with diffuse citron yellow pigment; caudal region transparent; small, stellate chromatophores along ventral margin of body at base of preanal finfold; characteristic pigment along margin of finfold.[22]

On eighth day after hatching, yellow pigment persists as a mid-lateral band from head to tail with black pigment above and below; at extreme end of trunk a rhomboidal yellow spot.[22]

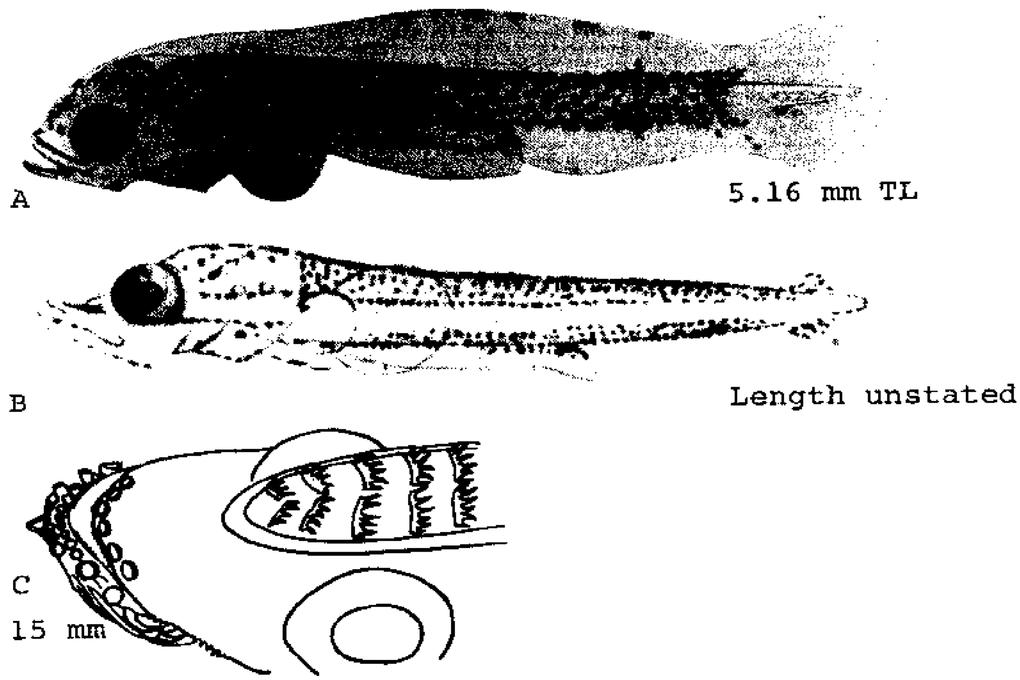

Fig. 126. *Remora remora*, Remora. A. Larva, 5.16 mm TL, three days after hatching. B. Larva, length unstated, seventh or eighth day after hatching. C. Larva, 15 mm, oblique view of head showing larval suckers on lip and developing teeth and cephalic disc. (*A, B, Sanzo, L., 1928: figs. 4, 5. C, Beebe, W., 1932: fig. 35.*)

JUVENILES

Fin rays complete by 15 mm,[5] number of disc lamellae (dorsal spines) in adult range by 18 mm TL.[19]

D. XVIII [3,5]–24 1/2; [5] A. 20 [11]–23 1/2; C. 9+8 at 88 mm; P. I, 26; V. I, 5.[5]

Body proportions as percent SL: Disc length 33 [3,5]–36, reducing with length; width of head 15–17; [5] length of head 28 [3,5]–30, reducing with length.[5]

Lateral line begins under 13th disc lamella, runs parallel and close to the cephalic disc descending to a mid-lateral position, over pectoral fin,[5] reaches this mid-lateral position near distal end of pectoral fin,[3] running straight posteriorly.[5] Pelvic fins not adnate as in adult.[3] Scales present on body, head and fins at 88 mm, small, concave on forward facing side, one or two small ones inserted at anterior base of larger ones.[5]

Pigmentation: In life, purplish brown with anterior portions of lips, tips of pectoral fins and outer tips of caudal lobes pale grayish.[5] In preservation, brown or black, small specimen with 18 darker transverse bands slightly angled forward, all fins transparent.[3]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Remorina albescens (Temminck and Schlegel), White suckerfish

ADULTS

D. XII to XIII (lamellae)—17–22;[5,8,9] A. 19[1]–26;[8,12] C. 9;[12] P. 16–21;[8] V. I, 5;[1] vertebrae 26;[8] gill rakers 100 on first arch.[12]

Body proportions as percent TL or SL: Depth 12.9–13.3 TL; head length 20.6 SL or 26.3 TL;[1] disc length 33.3[9]–37.6 SL; eye 2.8 SL; preanal fin length 68.1 SL.[12]

Body robust with short, thick caudal peduncle;[12] head broad,[5,9] strongly flattened;[12] gape to a vertical from the third disc lamella.[11] Two rows of close-set, flattened teeth along median half of premaxillary on outer edge, a broad band of small, pointed teeth along whole border; in lower jaw, 2 outer rows of strong, curved, pointed, wide-set teeth with a very wide band of smaller, pointed teeth inside, outer teeth of vomer and palatines similar to outer teeth of lower jaw, inner area with close-set, minute teeth, whole tongue and pharyngeals covered with minute, pointed teeth. Scales very small, cycloid, very few slightly covering each other, fairly regularly arranged and more or less equal in size; lateral line scales club-shaped, very small, not touching.[12] Caudal fin truncate; first 3 or 4 pectoral rays osseous.[1]

Pigmentation: Uniform gray,[1] grayish brown[1,8] or pigmentless;[3,5,8] iris yellow,[1] pupils black;[8] fins and lower regions varied with whitish and grayish tints, pectoral fins with white margins.[1]

Maximum length: To 305 mm.[5,8,9]

DISTRIBUTION AND ECOLOGY

Range: Circumtropical.[10]

Area distribution: New Jersey.[1,7]

Habitat and movements: Adults—in gill chamber of large fish or devil rays,[5,1] prefer *Mobula*[3] and *Manta*;[1,9] taken as deep as 40 m.[3]

Larvae—pelagic, down to 25–50 m.[4]

Juveniles—no information, presumably same as adult (FDM).

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

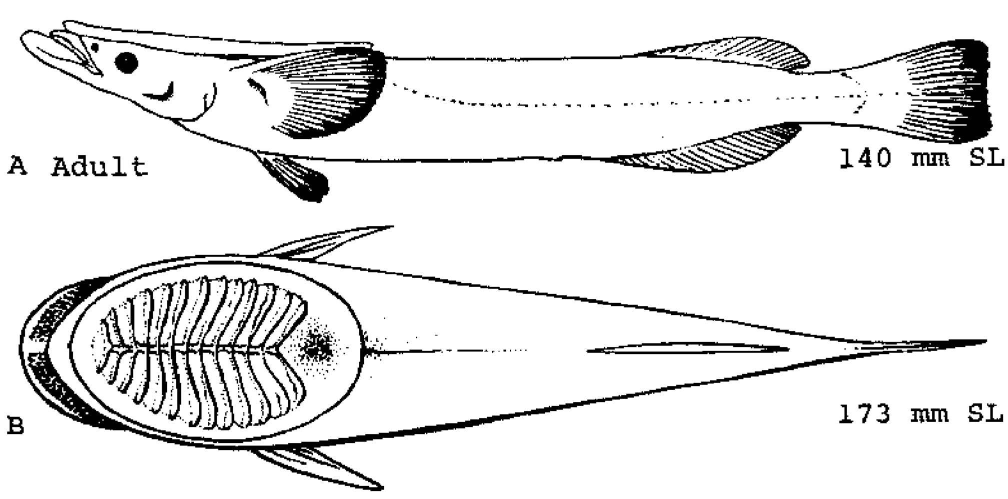

Fig. 127. *Remorina albescens*, White suckerfish. A. Adult, 140 mm SL, lateral view. B. Adult, 173 mm SL, dorsal view. *(A, Maul, G. E., 1956: fig. 5. B, Fowler, H. W., 1935: p. 115.)*

LARVAE

No information.

JUVENILES

95 mm TL [6] to 203 mm.[2]

D. XII–XIII 16–17; A. 20–21; 8 rakers on first arch.[6]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Gobiesox strumosus

clingfishes
Gobiesocidae

FAMILY GOBIESOCIDAE

Fishes of this family are mostly shallow water forms occurring in warm temperate and tropical rocky shore areas. Their adaptations to the surge of the intertidal zone are obvious in their thoracic sucking disc and their flattened tadpole shape. A few, more box-shaped than others, are adapted to deeper waters while still others, more elongate than most, are adapted to live among the spines of sea urchins. Other atypical habitats are freshwater streams and seagrass beds. While not rare they are frequently overlooked because of their habitat and protective coloration. Within the area the sole species is the wide-ranging ***Gobiesox strumosus***. This species is common within its habitat, oyster reefs, yet reportedly there are large numbers of fishermen within the area who have never seen this species and who would consider it a novelty were they to encounter one. Their role in the ecology of the oyster beds is almost completely unknown and may well prove interesting when that work is done.

Gobiesox strumosus Cope, Skilletfish

ADULTS

D. 9 [3]–11 [3,5,19,20] or 12; [4,6] A. 8–10; [3,6] C. total 20–23,[5] 10–12 primaries, 10–12 procurrent rays; [3] P. 21 [3,5,19]–23 [3] or to 26; [4] V. 4; no scales; vertebrae 13+14 [3] or 14+11–12 totals 25–26 [20] or 26–27.[3]

Body proportions as percent SL or HL: Head length 35.6 [3]–45.4 SL; body depth 20.0–22.7 SL; [4] preanal length 69.2–72.5 SL; disc length 35.1–37.8 SL; [3] eye 12.0–13.7 HL,[4] 5.6–6.8 SL.[3]

Body anteriorly broad, depressed, posteriorly compressed; [6] head broad, depressed; snout blunt; eyes small, superior; [3] mouth wide, inferior and horizontal,[6] lower lip projecting, with 12 papillae; [3] gape to middle of eye.[6] Teeth in upper jaw 14–16 on each side, all conical, largest 6–8 anterior, irregular in placement and size; no palatine or vomerine teeth; 13–14 teeth in each lower jaw, frontal ones incisor-like. Unpaired fins fleshy and widespread, pectoral fins membranous.[3]

Pigmentation: Considerable ability to change coloration; ranges from pale ochre [3] to black (JCB); lateral surfaces usually with reticulations; ventral surfaces with few melanophores, pearly tints; disc papillae change from white to yellow with age; base of tail quite dark; caudal fin often with 3 or 4 uneven darker bands; dorsal and anal fins varying greatly in pigmentation, light with darker bases and sometimes bars; pectoral and pelvic fins generally pale, though sometimes with small melanophores along edges of fin rays; [3] may have black streaks in back of eye.[5]

Maximum length: To 102 mm.[6]

DISTRIBUTION AND ECOLOGY

Range: New Jersey to Santos, Brazil including the Gulf of Mexico,[3,4] West Indies and Bermuda.[3]

Area distribution: New Jersey; [10,14] Atlantic coast of Maryland [13,18] and Virginia; [18] Chesapeake Bay south of the Magothy River.[6]

Habitat and movements: Adults—estuarine and marine,[3] *living around rocks,*[3,4] *pilings,*[3,4,5] *oyster shells and loggerhead sponges, also on eel grass;* [3] absent inshore in winter in Louisiana; [7] 0 [16]–36.8 ppt salinity; [15] 4.3 [8]–29.0 C; [12] to 33.5 m depth,[6] strictly inshore.[17]

Larvae—in water column only while swimming, dropping to bottom between swimming bouts; [8] 4 [8]–27.2 ppt salinity; [3] 17 [8]–37 C.[3]

Juveniles—little information, reported from 27.2 ppt salinity and 37 C.[17]

SPAWNING

Location: Takes place in empty oyster shells.[2,3]

Season: April through August [3,9] with a peak in late April or early May.[9]

Time: All spawning in aquaria within the daylight hours.[11]

Temperature and salinity: Spawn over range 18 [3] to 28.3 C and salinity range of about 15 ppt [3,9] to 30 ppt.[11]

Notes: Eggs deposited one at a time at 2–5 second intervals; [11] laid in a mass, single layer with oldest eggs toward center of mass; frequently deposited on surfaces so that the fish depositing the eggs must be upside down during egg placement.

Fecundity: Over successive periods a female may deposit 300–2500 eggs, a 53 mm female contained 1600 large yolked eggs; [3] 11 successive spawnings of a single 41 mm SL female varied from 300 to 1126 eggs with a mean of 645.[11]

EGGS

Location: Demersal, attached to empty oyster shells and guarded by male,[2] usually attached to concave surface of shell; masses contain 650–2500 eggs.[3]

Large yolked ovarian eggs: 0.66–0.76 mm, average 0.71 mm.[3]

Fertilized eggs: Ovate, occasionally spherical or ovate-elongate, somewhat flattened on side of attachment; appear yellow because of yolk; when oval .67×.94, when spherical .75–.94 mm; surface membrane finely corrugated; very adhesive, usually cannot be pried from site of attachment without breaking egg; attachment by mucus, probably developed by ovarian follicle; yolk yellow, granular, appearing to be multicellular; oil droplets 70–80, 0.02–0.10 mm diameter; perivitelline space 15–20% of egg; cleavage meroblastic.[3]

EGG DEVELOPMENT

Eggs collected at 25.6 C, maintained at 23.3–24.4 C; water hardened but not cleaved at the beginning of observations. Times given from collection time.

- 2 hours—first cleavage complete in most.
- 3 hours—second cleavage complete in most; blastodisc prominent and rounded; rounded blastomeres well defined units; oil droplets coalesced to 30–60; migrated to negative pole.
- 4 hours—third cleavage complete in most; blastomeres in a single layer, forming two rows of four

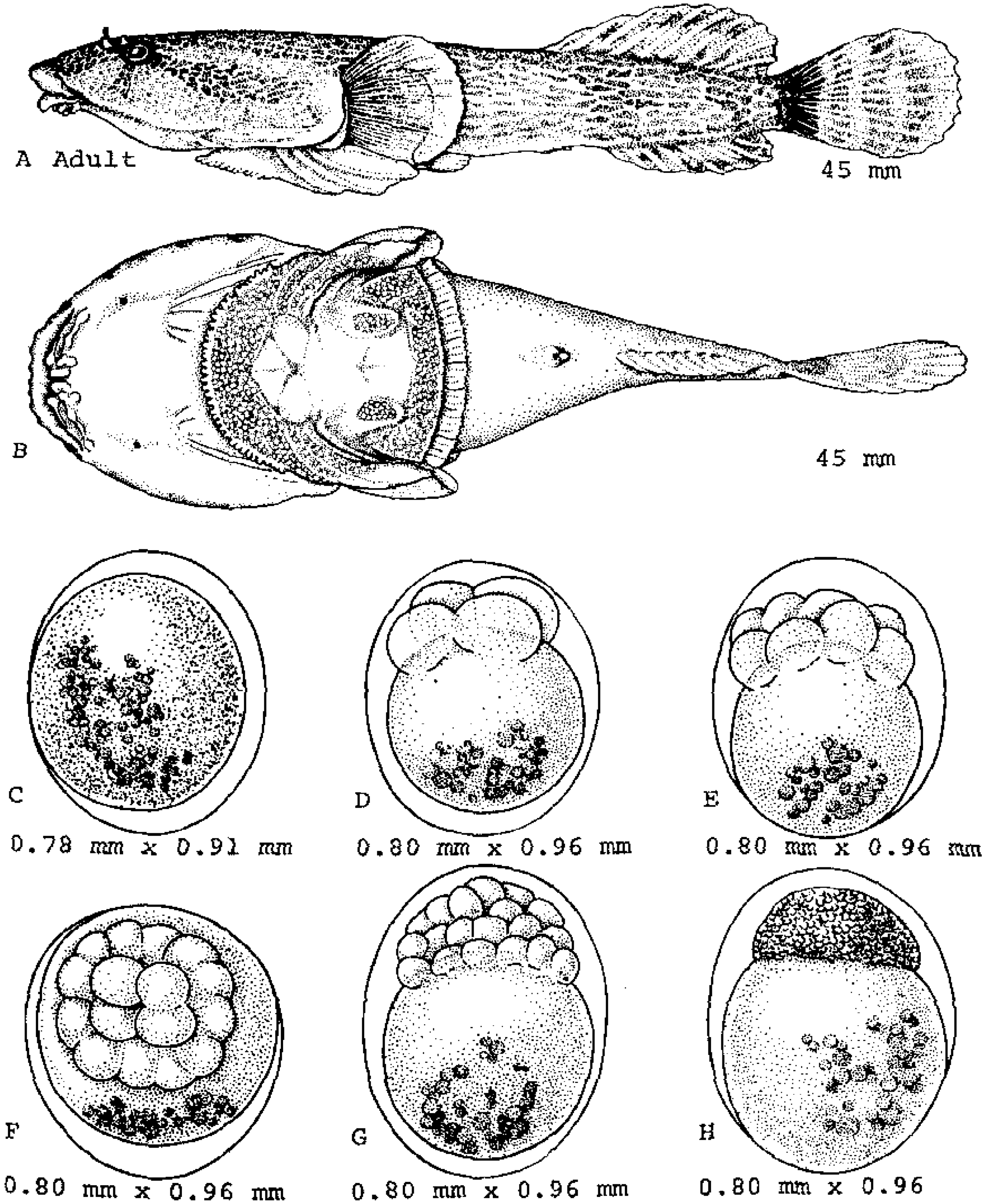

Fig. 128. *Gobiesox strumosus*, Skilletfish. A. Adult, 45 mm. B. Adult, 45 mm, ventral view, showing form and structures of ventral sucking disc. C. Egg, 0.78 mm x 0.91 mm, prior to cleavage. D. Egg, 0.80 mm x 0.96 mm, four-cell stage. E. Egg, 0.80 mm x 0.96 mm, eight-cell stage. F. Egg, 0.80 mm x 0.96 mm, dorsal view, 16-cell stage. G. Egg, 0.80 mm x 0.96 mm, 32-cell stage. H. Egg, 0.80 mm x 0.96 mm, morula. (*A-H, Runyan, S., 1961: figs. 23A, 23C, 2, 3, 4, 5, 6, 7.*)

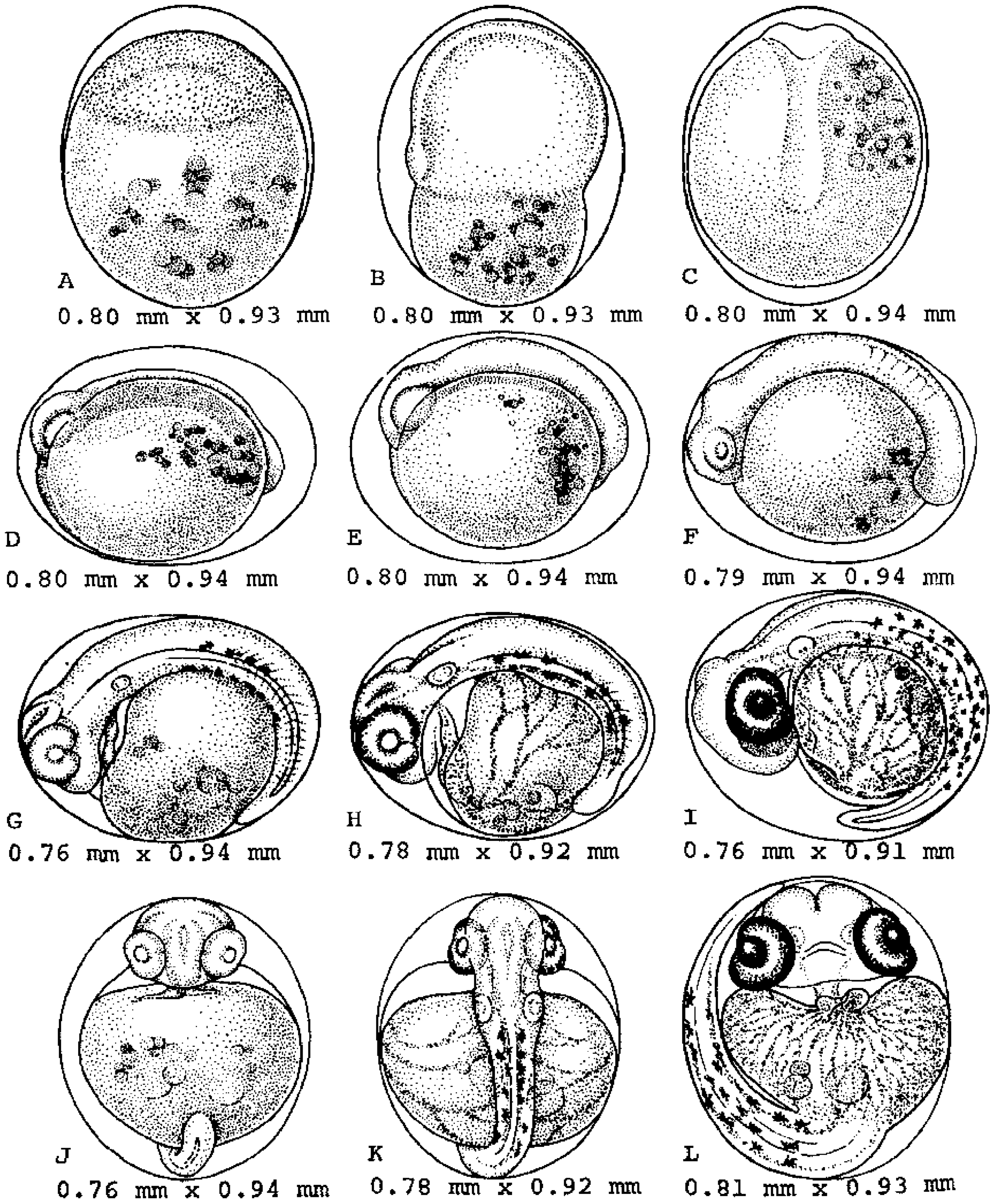

Fig. 129. *Gobiesox strumosus*, Skilletfish. A. Egg, 0.80 x 0.93 mm, germ ring and embryonic shield stage. B. Egg, 0.80 mm x 0.93 mm, early neurulation. C. Egg, 0.80 x 0.94 mm, same as previous figure, except posterior view. D. Egg, 0.80 mm x 0.94 mm, optical anlagen visible. E. Egg, 0.80 mm x 0.94 mm, early embryonic stage. F. Egg, 0.79 mm x 0.94 mm, somites forming, mesencephalic swelling visible, eye cup forming. G. Egg, 0.76 mm x 0.94 mm, otocyst, heart and pigment visible, mesencephalon differentiated. H. Egg, 0.78 mm x 0.92 mm, eye pigment and vitelline circulaton developing. I. Egg, 0.76 mm x 0.91 mm, vitelline circulation well developed. J. Egg, 0.76 mm x 0.94 mm, ventral view of fig. C. K. Egg, 0.78 mm x 0.92 mm, ventral view of fig. H. L. Egg, 0.81 mm x 0.93 mm, ventral view of fig. I. (*A-L, Runyan, S., 1971: figs. 8, 9, 10, 11, 12, 13, 14, 15, 16.*)

cells each.

5 hours—fourth cleavage complete in many; blastomeres (observed dorsally) comprise a well-contained, compact ring; germinal area about 1/3 of actual egg substance.

6 hours—eggs at 32-cell stage and beyond; amount of perivitelline space and number of oil droplets still constant.

7 hours—64 to 128-cell stages although cells smaller, blastoderm maintains its previous volume.

8 hours—blastoderm flattened somewhat and egg in morula stage, cells form a compact, berry-like mass.

A second batch of eggs was obtained at end of gastrulation and beginning of neural groove formation, though some eggs were developing embryonic shield and downwardly expanding the germ ring. Obtained at 18.9 C and maintained at 18.9–20.6 C. Times are estimated elapsed time since oviposition; estimated to be 20 hours old at collection time.

24 hours—primitive streak and neural groove extending almost halfway around yolk substance; cephalic and caudal swelling visible; optic vesicles forming; oil droplets remain clustered in caudal region of yolk.

28 hours—yolk becomes more spherical; embryo well lifted off underlying yolk; forebrain formation quite evident.

36 hours—embryo wrapped 2/3 around yolk; midbrain development as a prominent hump; optic placodes in process of formation; oil droplets coalesced to 10–20; 6–8 somites visible just behind midbody region.

3rd day—embryo about 3/4 around yolk circumference; brain lobulation clearly visible; choroid fissure developed; auditory placode present but

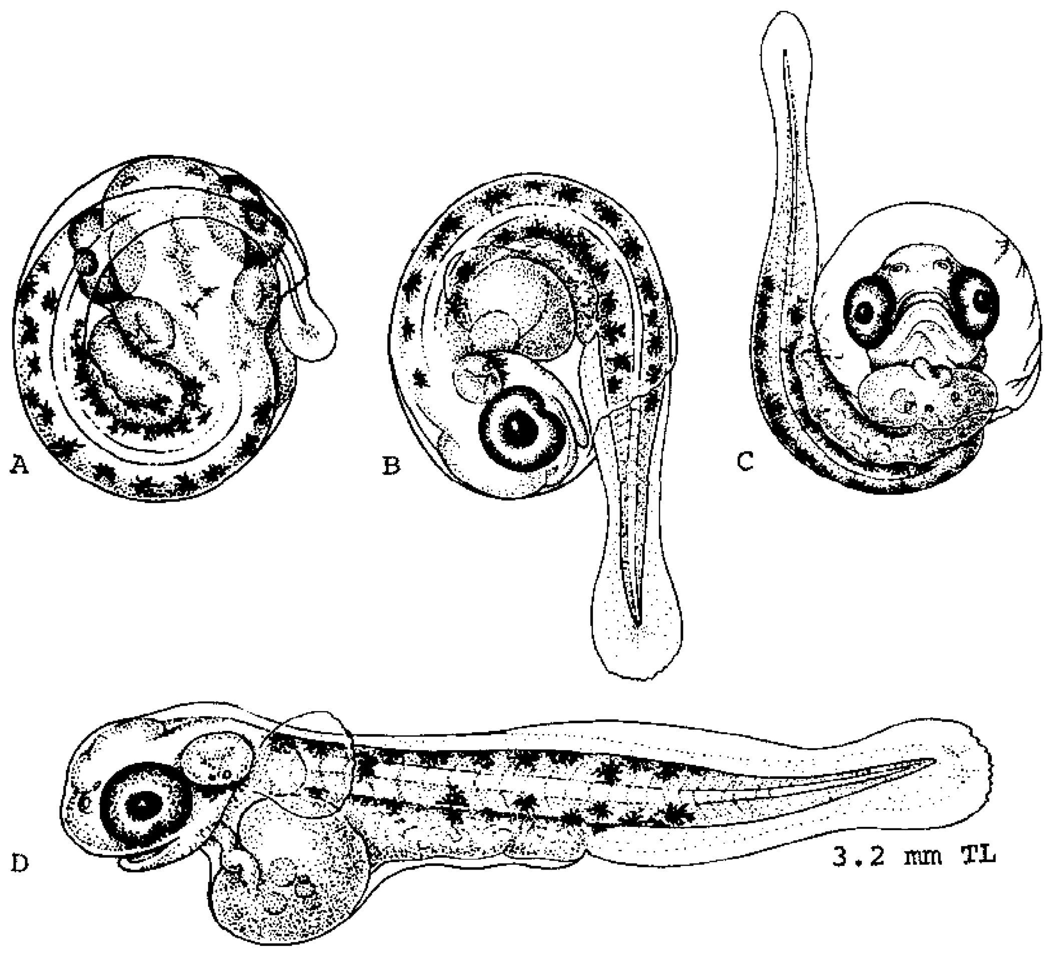

Fig. 130. *Gobiesox strumosus*, Skilletfish. A. Egg, hatching, egg diameter 0.82 mm x 0.96 mm, embryo 3.2 mm, dorsal view. B. Egg, hatching, lateral view, at slightly later time of fig. A. C. Egg, hatching, ventral view, a still later stage of figs. A. and B. D. Yolk-sac larva, 3.2 mm TL, incipient caudal rays indicated. (*A-D, Runyan, S., 1961: figs. 18, 19.*)

small; rudimentary heart beating slowly; circulatory system undeveloped; 15 somites clearly defined in caudal region, but advancing forward, become less distinct; pigmentation a few small melanophores above and below the notochord at about mid-body.

3 1/2 days—*eyes becoming pigmented*; auditory placodes larger and more distinct; circulatory system developed; oil droplets coalesced to 4–10 in ventral yolk region; somites less distinct, visible only in caudal region; melanophores increase somewhat in number, size and definition; embryo shows slight movement of trunk and tail.

5th day—embryo virtually filling egg with tail wrapped around sides of body and head region; eyes heavily pigmented, large; two otoliths formed in auditory placode; mouth undeveloped; heart situated in frontal concavity of yolk sac and pulsating rapidly; the few remaining oil droplets quite large; somites no longer visible; pigmentation in the form of rows of melanophores confined to anterior 2/3 of body behind yolk, none on head of yolk; active.

7th day—just prior to hatching embryo cramped, wrapped around itself, mouth and external nares developed; most of yolk absorbed; pigmentation darker, more concentrated on trunk; some with 1 or 2 faint melanophores on dorsum of head behind eye.

Hatch tail first; late embryos typically ventral side up.[3]

Incubation period: 5–7 days at 18.9–24.4 C [3,11] with all eggs in one clutch hatching over a 10 hour period.[11]

Normal development was noted up to 25.8 C and in the salinities 19.8–20.7 ppt.[2]

YOLK-SAC LARVAE

In one experiment, hatched at 2.4–2.8 mm, mean of 2.7 mm; [2] in another, hatched at 2.85–3.40 mm with yolk already absorbed; if hatched with yolk, yolk sac absorbed by 3.9 mm.[3]

Pectoral with 6–8 rays at hatching; 13–14 preanal myomeres at hatching, 14–15 at 3.5 mm; 21–23 postanal myomeres at hatching, 27–29 at 3.5 mm.[3]

Body proportions at hatching, preanal length 60% SL; eyes 52% HL; head 21% SL; yolk sac length about 16% SL.[3]

Body slightly curved; yolk sac 0.26–0.57 mm in individuals 2.85–3.40 mm long. Mouth well formed and horizontal at hatching; gape to midorbital region; [3] gut relatively short; [7] no gas bladder; gall bladder obvious at 3.5 mm.[3]

Pigmentation: At hatching eyes jet-black, flecked with orange and green pigment; finfold and pectorals transparent and unpigmented; melanophores arranged in two definite rows above and below notochord, stopping shortly beyond anus; one large melanophore on ventral border of otocyst.

At 3.5 mm large, stellate melanophores on surface more distinct, 10–15 situated along dorsum of body extending from back of head to about 0.35 mm beyond anus; also a definite row of melanophores along groove between notochord and visceral mass and between notochord and finfold.[3]

LARVAE

3.9 mm [3] to about 9 mm.[9]

13 or 14 preanal myomeres, body slender,[3] more robust at 4.73 mm; all branchiostegal rays present by 7.0–7.49 *mm; dorsal fin with some rays at 7.00–7.49 mm*, complete adult complement at 9.0 mm; anal fin with some rays at 7.00–7.49 mm, complete adult complement at 8.0 mm; first caudal fin rays at 4.5–4.99 mm, complete adult complement at 9.00–9.49 mm; pectorals with 9 rays at 7.0 mm; full adult complement by 9.0 mm; pelvic fins present as ridges at 6.58 mm, first rays formed at 7.5–7.99 mm, full adult complement by 9.0 mm.[9] Disc well formed but incomplete at 8.78 mm.[9] Finfold moved more posteriorly at 3.9 mm,[3] still rudiments of finfold at 8.78 mm. Hypural plates developed and ossified at 6.58 mm.[9]

Pigmentation: At 3.9 mm, 3 or 4 small melanophores on ventral finfold near urostyle; some pigmentation between nostrils; trunk with some chartreuse flecks.[3] At 4.73 mm melanophores in ventral finfold missing; portions of ventral finfold from which anal fin will develop with *developing chromatophores. At 6.58 mm* posterior quarter of larva unpigmented; one large melanophore on ventral region about where disc will be.[9]

JUVENILES

From about 9 mm [9] to 40–45 mm.[3]

Centra not ossified at 12 mm except in rearmost caudal region, but all vertebrae represented by ossified neural and haemal arches and spines.[3]

Head width 36.6% SL at 12 mm, 40% at 36 mm (within *adult range); head length within adult range* at 12 mm; eye 8.2% SL at 12 mm, 6.5% at 38–40 mm; disc length 29.1% SL at 12 mm, 35% at 38–40 mm.[3]

Body tadpole-shaped; viewed dorsally, like a rounded triangle with greatest width at opercles, body tapering to a compressed caudal peduncle; head not depressed at 12 mm, broader and snout more blunt at 20 mm becoming somewhat flattened; upper lip scalloped, with a prominent premaxillary groove; lower lip with 8 sen-

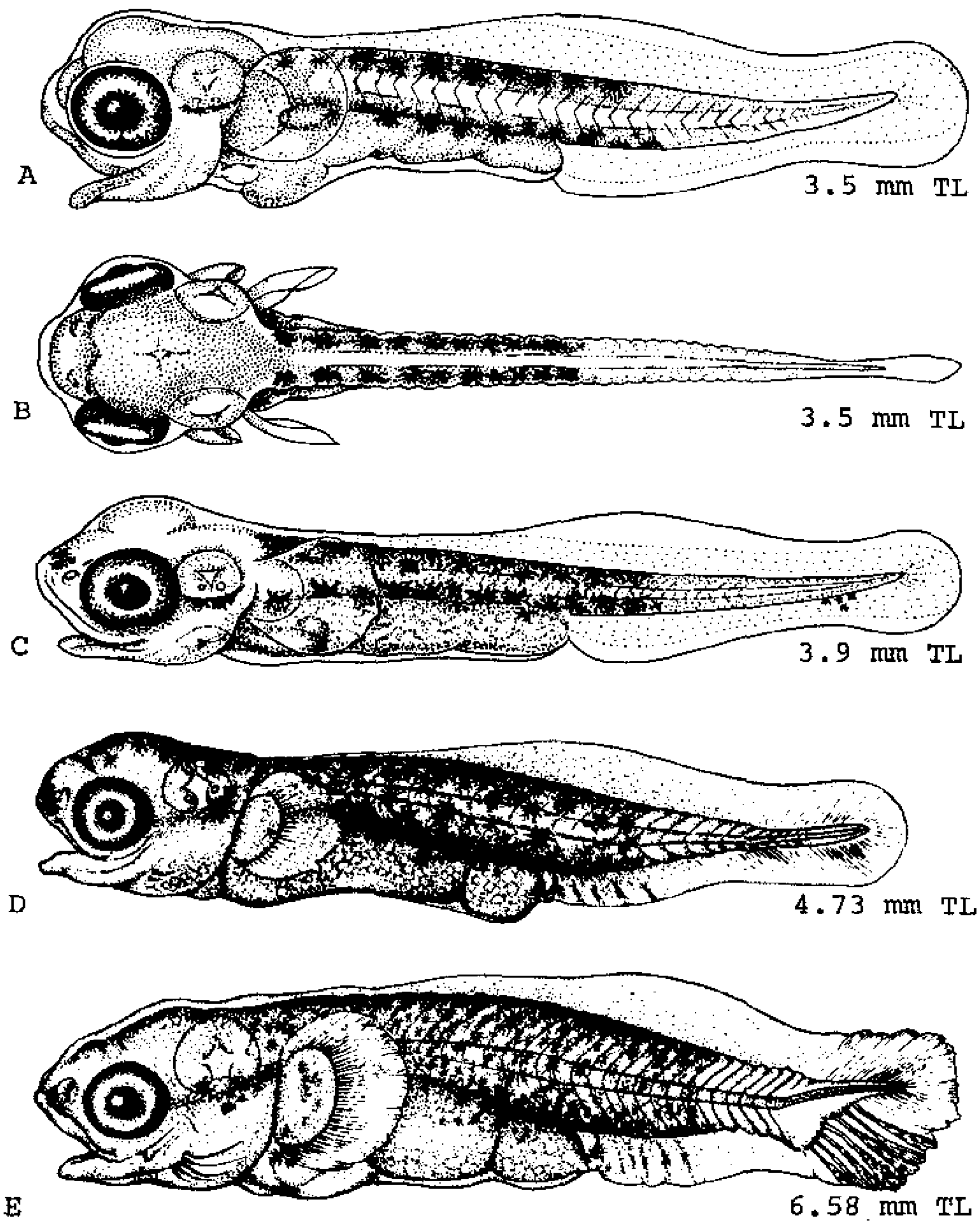

Fig. 131. *Gobiesox strumosus*, Skilletfish. A. Yolk-sac larva, 3.5 mm TL. B. Yolk-sac larva, 3.5 mm TL, dorsal view. C. Larva, 3.9 mm TL. Pigment indicated near notochord posterior tip is atypical. D. Larva, 4.73 mm TL, incipient anal rays may be indicated. E. Larva, 6.58 mm TL, flexion occurring. (*A-C, Runyan, S., 1961: figs. 20, 21. D, E, Dovel, W. L., 1963: figs. 1, 2.*)

sory barbels; mouth wide, inferior and horizontal; gape to anterior margin of eye. At 12 mm premaxillary ossified but not the maxillary. At 12 mm adhesive disc bordered with 30 coarse cirri, some crenulations before bending with the edge of the ventral fin, both anterior and posterior collars of disc with 6–8 staggered rows of indistinct papillae. At 20 mm dorsal, anal and caudal fins more fleshy but still somewhat flat and without flair. At 20 mm rugal folds develop around the anus.[3]

Pigmentation: Fins transparent with no pigmentation except pelvics.[3] At about 9 mm, 7 large chromatophores between anal fin rays.[9] At about 12 mm dorsal and lateral surface stippled with numerous stellate melanophores; undersurface pale with only a few stellate melanophores scattered randomly, usually some around

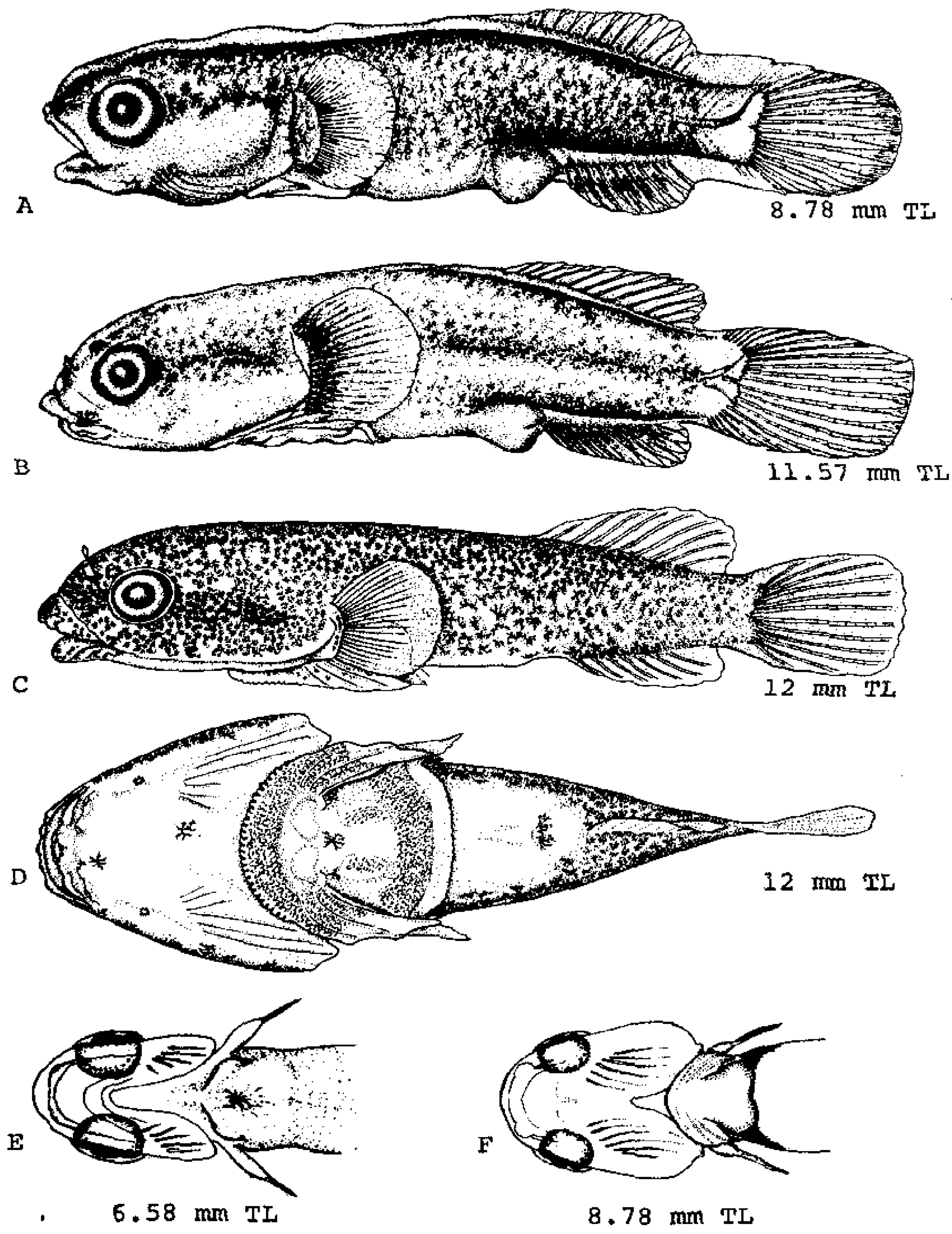

Fig. 132. *Gobiesox strumosus*, Skilletfish. A. Larva, 8.78 mm TL, late flexion, dorsal and anal rays forming. B. Juvenile, 11.57 mm TL. C. Juvenile, 12 mm TL. D. Juvenile, 12 mm TL, ventral view showing the ventral sucking disc to be essentially complete. E. Larva, 6.58 mm TL, ventral view of head and thorax showing a large stellate melanophore where the ventral sucking disc will form. F. Larva, 8.78 mm TL, ventral view of head and thorax showing developing ventral sucking disc. *(A, B, E, F, Dovel, W. L., 1963: figs. 3, 4, 5, 6. C, D, Runyan, S., 1961: fig. 22.)*

anus. At 20 mm melanophores smaller and less distinct, beginning to fuse into faint patterns; 3 or 4 darker streaks radiating from orbital region and a few scattered bars of pigment present on dorsal, anal and caudal fins.[3]

GROWTH

Between June and October, mode shifted from between 16–20 mm to between 32–36 mm indicating a growth of 16–20 mm over 4 months.[3]

AGE AND SIZE AT MATURITY

Smallest female with eggs 34.9 mm; [6] both sexes mature by 40–45 mm.[3]

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Aluterus monoceros
Aluterus schoepfi
Balistes capriscus
Balistes vetula
Stephanolepis hispidus

triggerfishes and filefishes
Balistidae

FAMILY BALISTIDAE

'his primarily tropical family is represented in the area by five species. of these are benthic species but enter the area at a pelagic stage and it is ful whether any of them breed within the area of consideration. Most of species are strongly laterally compressed and relatively deep bodied with a head. The larvae, where known, take on this body form quite early and .us easily recognized.

Aluterus monoceros (Linnaeus), Unicorn filefish

ADULTS

D. II, 46–50; A. 47–52;[5,13] C. 12, 6+6;[11] P. 14–15;[5] V. represented only by a rudimentary spine, absent in large specimens;[13] vertebrae 23, 7+16;[11] gill rakers about 31.[5]

Body proportions as percent SL: Head length 26.6–34.7; depth of body 34.4–43.8; snout 23.4–27.5; eye 4.2–8.3.[13]

Body oblong,[4] *compressed;*[1] *snout moderately produced* with convex profile above,[4] ventral outline concave below chin followed by a prominent concavity.[5] First dorsal *spine inserted over middle or posterior part of eye;*[13] caudal fin short, sub-truncate with acute angles.[3]

Pigmentation: Background color dull bluish gray,[1] gray,[2,3] brown[4,5] or black,[4] uniform[2] or with yellowish white to white below; may be mottled with dark; covered with small dark spots,[5] either roundish[2] or irregular *in shape;*[3] *fins may be yellowish*[4] *though caudal fin may* be bluish gray with dark crossbars.[1]

Maximum length: To 762 mm.[7]

DISTRIBUTION AND ECOLOGY

Range: Cosmopolitan in warm seas,[3,5,8,13] straggling as far north as Massachusetts.[1]

Area distribution: New Jersey[6,9] and about the southern boundary of Virginia.[13]

Habitat and movements: Adults—shallow rocky areas, coral and over mud,[2] also associated with open ocean flotsam.[10]

Larvae—no information.

Juveniles—associated with open ocean flotsam.[10]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Specimens reported from 53 to 72 mm SL.

Dorsal fin 46–48; anal fin 47–50.[12]

Head length 32.2–34.5% SL; maximum body depth 44.4–47.6% SL; eye diameter 20.0–23.5% HL; snout 76.9–83.3% HL.[12]

Dorsal spine with spinules which disappear with age;[13] caudal fin rounded; pelvic spine rudimentary.[5]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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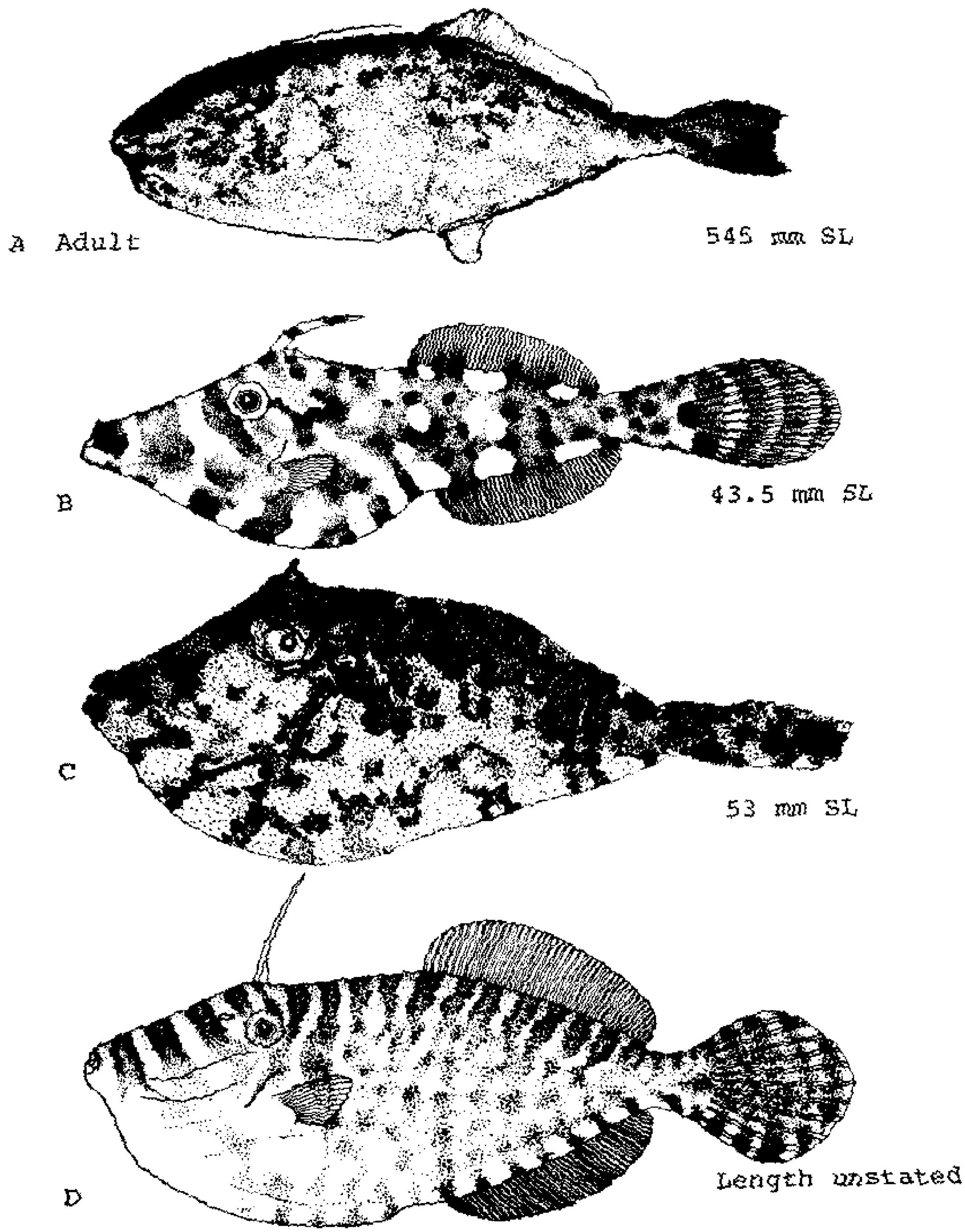

Fig. 133. *Aluterus monoceros*, Unicorn filefish. A. Adult, 545 mm SL. B. Juvenile, 43.5 mm SL. C. Juvenile, 53 mm SL. D. Juvenile, *length* unstated. (*A, C, Berry, F. H., and L. E. Vogele, 1961: figs. 21, 19, delineated by Tamiko Karr. B, Fowler, H. W., 1944: fig. 264. D, Fowler, H. W., 1949: fig. 6.*)

Aluterus schoepfi (Walbaum), Orange filefish

ADULTS

D. II, 32–29; [1,3] A. 35–41; [3,6] C. total 12, 6 + 6,[24] P. 11–14 [1,3] with one rudimentary spine; V. absent at all sizes; [1] vertebrae total 23,[24,28] 7 + 16; [24] gill rakers 21–27.[3]

Body proportions as percent SL or HL: Depth 17.3 [1]–47.6 [3] SL; head length 23.3–34.2 SL; snout 12.0–28.6 SL; eye 4.8–8.8 SL [1] or 18.5–26.3 HL.[7]

Body somewhat oblong,[8] very strongly compressed; [7] head scarcely distinguishable from body, snout bluntly rounded,[6] dorsal profile nearly straight to noticeably concave in small to medium sized individuals, concave over snout and convex over eyes in individuals over 400 mm; mouth small, almost terminal, lower jaw projecting. Teeth in upper jaw incisor-like, in a double series, in lower jaw incisor-like, uniserial,[4] teeth in lower jaw usually notched.[7] Scales minute, rough, shagreen-like and uniform in size over the whole body.[4,6] Lateral line indistinct. First dorsal spine inserted over eye; soft dorsal fin separated from spinous dorsal by a gap about equal to the length of the soft dorsal fin base; caudal fin mod-

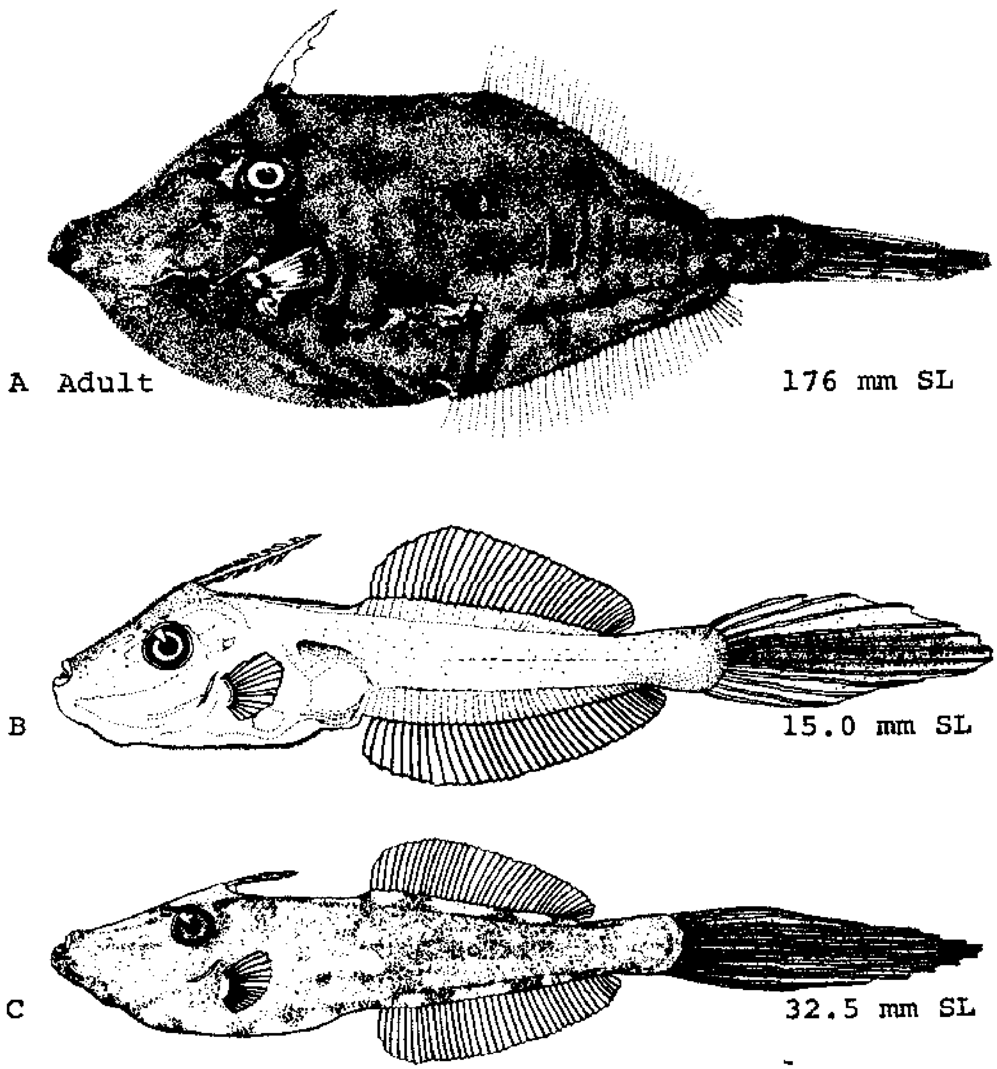

Fig. 134. ***Aluterus schoepfi***, Orange filefish. A. Adult, 176 mm SL, color pattern atypical in that orange spots are missing. B. Juvenile, 15.0 mm SL, barbs on dorsal spine large. C. Juvenile, 32.5 mm SL, barbs on dorsal spine reduced, dorsal spine itself reduced, color developing. *(A–C, Berry, F. H., and L. E. Vogele, 1961: figs. 23, 10, 11. Fig. 23 delineated by Tamiko Karr.)*

erate, rounded; anal fin origin under origin of soft dorsal; pectoral fin small, rounded, under gill slit.[6]

Pigmentation: Body color variable, orange,[1,8] orange yellow,[6,14] dark brown,[3,8] various shades of gray,[1,2,3,6,7,14,15] to white; [1,14] may be marbled with lighter shades [6,15] or darker shades; [15] usually with orangish spots in life,[1,2,3,15] spots may be dusky or brownish; [7,8] tip of rostrum darker; [2] lips often blackish; [3] nape plain or dusky; [7] when white present, usually most prevalent over anterior region of fish; [1] dorsal fin colorless [2] or tinged with yellow brown; [7] caudal fin usually yellowish but may be dusky, edged with white; [6,14] anal fin colorless, outer edge tinged with brown, pectoral fin plain.[7]

Maximum length: To 610 mm.[6,7,8,14,15]

DISTRIBUTION AND ECOLOGY

Range: Nova Scotia and Bermuda to Brazil and all of the Gulf of Mexico.[2,15]

Area distribution: New Jersey,[4,12,16] Delaware Bay,[18] Atlantic coasts of Maryland [17,21,23] and Virginia [11,13] and lower Chesapeake Bay [7,21] northward to the Patuxent River.[9]

Habitat and movements: Adults—on sand and around seagrasses,[3,13] over mud,[3] around pilings and jetties,[17] coral or rocky reefs; [2] 16.4 [9]–42.9 ppt salinity; [10] 12.8 [9]–32.5 C; surface [22] and shallow flats [5] to 88 m.[15]

Larvae—no information.

Juveniles—pelagic,[21] in sargassum mats; [2,5,15] reported from 22.5 ppt salinity and over 30 C.[19]

SPAWNING

In the Caribbean ripe females found throughout the year.[25]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Depth changes from 20.8% TL at 38 mm to 30.3% TL at 70 mm to 38.5% TL at 100 mm.[5]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Balistes capriscus Gmelin, Gray triggerfish

ADULTS

D. III, 26–29;[27] A. 23[2,4,12]–26;[27] C. total 12, 6 + 6;[25] P. I, 13–15; scales 48–53;[27] vertebrae 18, 7 + 11;[22,25] gill rakers 31–35;[2] 8 premaxillary and 8 dentary teeth,[27] 4 incisor-like teeth in each jaw;[5] 6–7 branchiostegal rays.[27]

Body proportions as percent SL, TL or HL: Head length 33.3[2]–37.4 SL, decreasing with length,[1] 25.0[5]–35.7[12] TL; depth 45.4 SL,[2] 44.4–58.8 TL;[12] eye 20.0[5]–22.7 HL;[6] 7.0–7.9 SL.[1]

Body short, deep, much compressed,[5] with a slender caudal peduncle,[14,24] head deep, snout long, tapering,[6] dorsal and ventral profiles almost straight;[5,14] eye placed high with a narrow groove before it;[12] mouth small, terminal,[5,6,14] lips thick. Large, strong, anteriormost teeth canine-like.[6] Head and body covered with scales, heaviest and armor-like below a line joining eye, lower edge of pectoral and vent;[5] edge of scales not free, each scale covered with bony barbs;[6] 2 modified scales above pectoral fin base, irregular in shape, several smaller modified scales above these.[27] Lateral line feebly developed,[6] undulating, irregular, a branch over the nape connecting the two lines,[24] branches over and under orbit,[27] best seen when scales are dry.[5] Vertical fins falcate;[12] dorsal fins separate, pelvic fin represented only by a single spine, pectoral fin short and rounded.[6]

Pigmentation: Color variable,[5] olive gray dorsally,[2,12] interspaces between scales paler;[12] violet or blue spots on upper back and median fins;[2,5] whitish spots and irregular short lines ventrally,[2] first dorsal fin spotted and clouded with bluish; second dorsal fin pale yellowish with sky-blue spots,[5] pectoral fins greenish.[5,12]

Maximum length: To about 49 cm.[5,23]

DISTRIBUTION AND ECOLOGY

Range: Both sides of the Atlantic, in eastern Atlantic and Mediterranean, north to England, Ireland[5,14] and rarely Belgium,[22] in western Atlantic from Nova Scotia and Bermuda to Argentina including Gulf of Mexico.[1,13]

Area distribution: New Jersey;[3,11,16] Delaware Bay;[18] Atlantic coast of Maryland,[17,21] lower Chesapeake Bay[21] to the mouth of the Potomac River.[6]

Habitat and movements: Adults—coral or rocky reefs;[1,15] little movement noted;[7] reported from 16.6[9]–40.1 ppt salinity;[8] 14[9]–33.2 C;[8] down to 55 m.[9]

Larvae—no information.

Juveniles—pelagic,[20] accompanying flotsam;[4] in sargassum mats,[1,19] primarily found at the surface.[20]

SPAWNING

Location: Eggs laid in a hollow nest scooped out of sand, guarded by adults.[26]

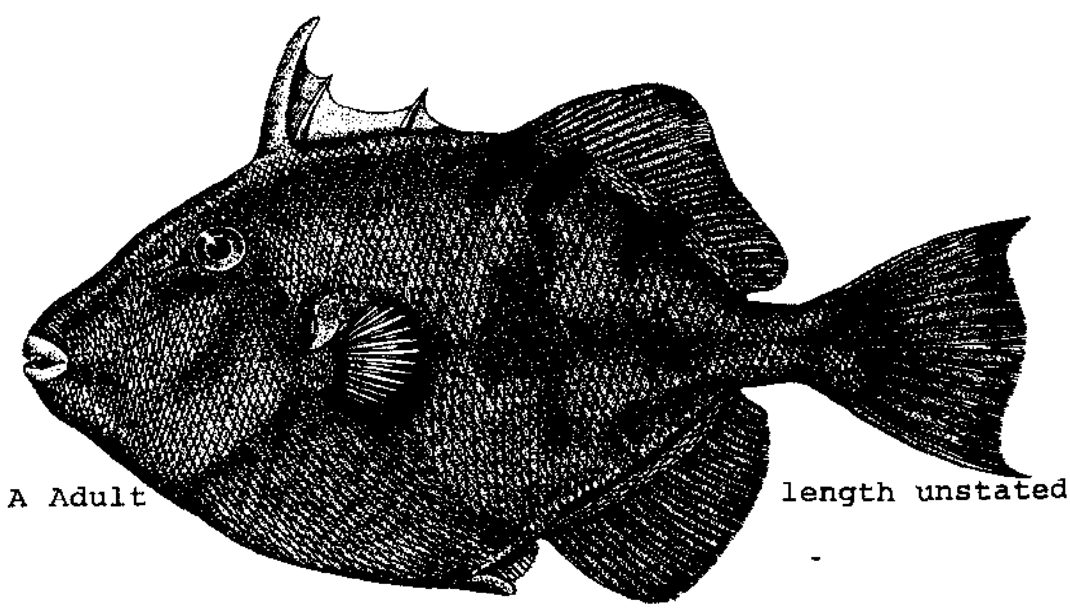

Fig. 135. *Balistes capriscus*, Gray triggerfish. A. Adult, length unstated. (*A, Poll, M., 1947: fig. 259.*)

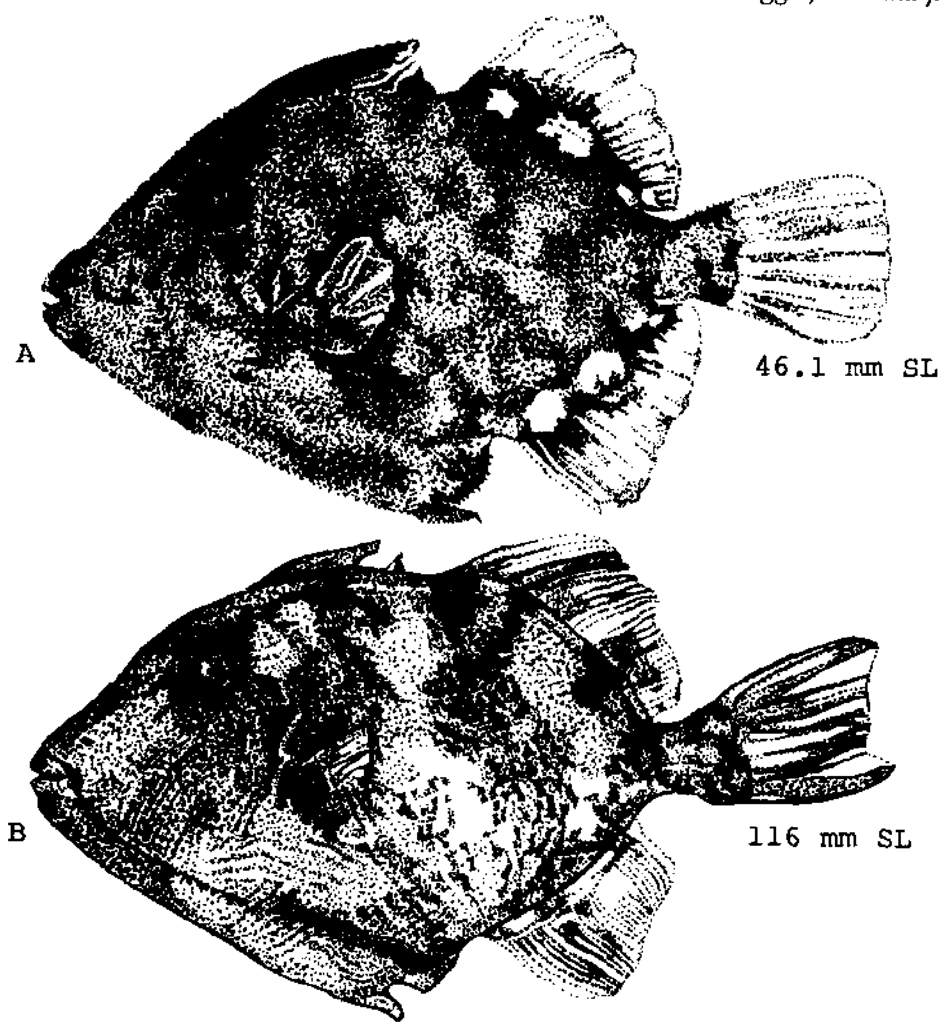

Fig. 136. *Balistes capriscus,* Gray triggerfish. A. Juvenile, 46.1 mm SL. B. Juvenile, 116 mm SL. (*A, B, Moore, D., 1967: fig. 1.*)

Season: Females with eggs have been taken in July,[6] spawning season thought to be July through September.[10] Spawning occurs only after the water temperature reaches 21 C.[26]

EGGS

No information.

EGG DEVELOPMENT

Incubation period: 2 days.[26]

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Reported as small as 9 mm.[10]

Snout length 19–21% SL at 10–20 mm SL, increasing with size; eye diameter 15–18% SL at 10–20 mm SL, decreasing with size; scales with single spines, these being lost between 25 and 40 mm SL.[27]

Pigmentation: Yellowish with many small, rounded violet dots;[14] less than 50 mm SL, with larger irregular dark patches on the body and the small spots;[27] fins tinted with yellow, blue and olive[14] or second dorsal, anal, and caudal fin membranes translucent and with saddle markings on dorsal and anal fins, these saddles interspersed with light spots.[27]

GROWTH

Adults grow about 3.6–10.6 mm SL/mo. in Florida with largest individuals growing slower.[7]

AGE AND SIZE AT MATURITY

No information.

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Balistes vetula Linnaeus, Queen triggerfish

ADULTS

D. III, 29–31, usually 30;[2,13] A. 26–28;[1,2,4,13] C. total 12, 6+6;[12] P. I, 14–15; scales 45–51,[13] about 36 scales between soft dorsal origin and anal fin;[9] vertebrae total 18, 7+11;[12,13] gill rakers 35–38;[2] 8 premaxillary and 8 dentary teeth.[13]

Body proportions as percent SL or HL: Body depth 41.7–55.6 SL;[2] head length 31.0[1]–37.0 SL;[2] eye 6.0–6.3 SL[1] or 21.3–28.6 HL;[1] snout 26–28 SL.[13]

Two enlarged modified scales above pectoral fin insertion of irregular shape, several smaller modified scales or plates above these. Lateral line complete, branches above and below orbit, uniting behind orbit and proceeds posteriorly to level of third dorsal spine where it turns downward reaching its ventralmost point.[13] Soft dorsal and upper and lower lobes of caudal with elongated, filamentous rays in adults.[5]

Pigmentation: Able to change colors, patterns and shades somewhat;[3] two broad curved bright blue stripes below eye in all color phases,[6] a series of small narrower bands above these;[4] a blue band from corner of mouth to under gill opening, turning downward;[2,4] dark blue lines radiating from eye; blue ring around lips;[2] broad blue band on caudal peduncle;[2,4,6] blue submarginal band on median fins;[2,6] posterodorsally greenish olive,[4] greenish,

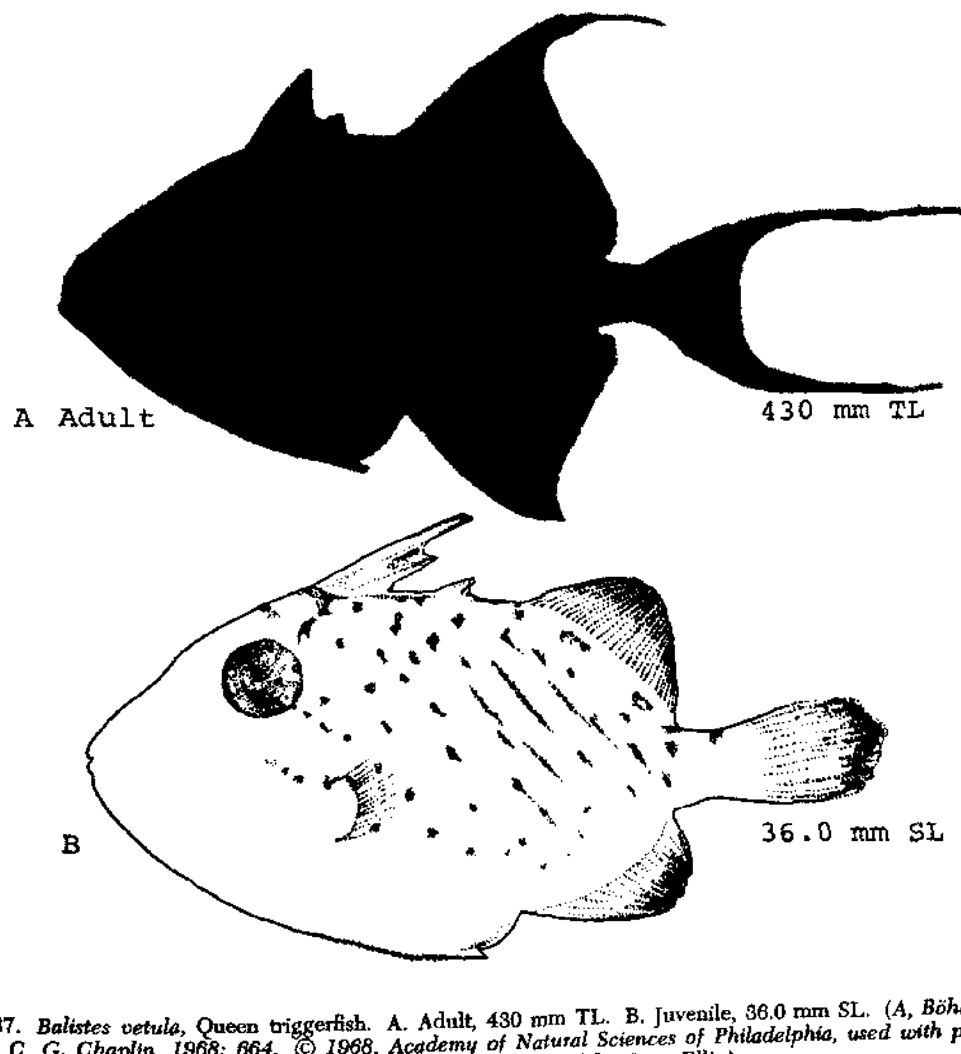


Fig. 137. *Balistes vetula*, Queen triggerfish. A. Adult, 430 mm TL. B. Juvenile, 36.0 mm SL. (*A, Böhlke, J. E., and C. C. G. Chaplin, 1968: 664. © 1968, Academy of Natural Sciences of Philadelphia, used with permission of authors and publisher. B, Moore, D., 1967: fig. 2C, delineated by Joan Ellis.*)

bluish gray,[2] yellowish brown, blue-green to deep brown;[6] throat and breast golden yellow;[4,6] salmon,[6] or orange yellow;[2] median fins pale grayish green to deep purplish brown;[6] may have a series of discontinuous stripes of brown separating rows of scales.[4]

Maximum length: To 572 mm FL.[2]

DISTRIBUTION AND ECOLOGY

Range: Both sides of the Atlantic; in western Atlantic from Massachusetts and Bermuda to Brazil, including the West Indies;[4] also reported from the Indian Ocean and western Pacific.[13]

Area distribution: New Jersey[7,11] and Atlantic coast of Maryland[8,10] and Virginia.[10]

Habitat and movements: Adults—around rocky or coral reefs in clear water,[1] around pilings and stone jetties,[5] venturing out into adjacent sandy, rubble or seagrass habitats;[2] depth to 46 m,[4] common at 3.6–4.8 m;[1] occasionally offshore.[4]

Larvae—no information.

Juveniles—no information.

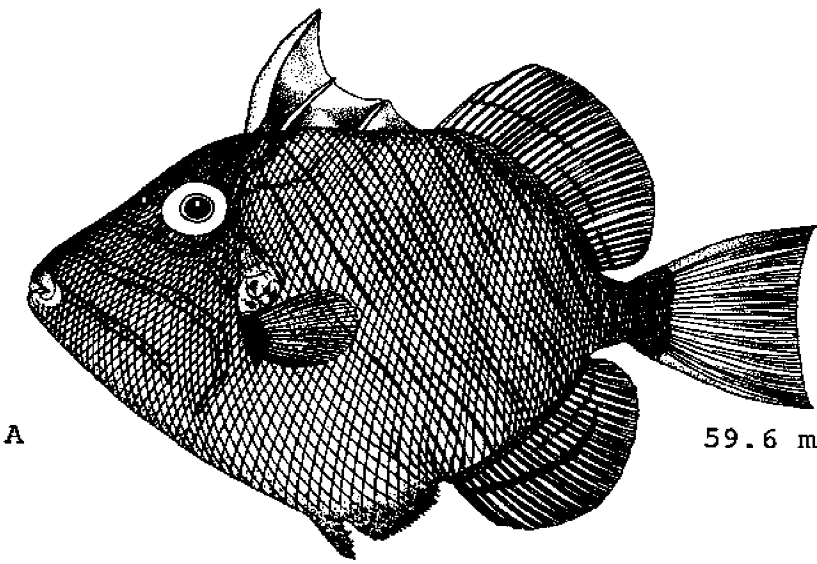
SPAWNING

No information.

EGGS

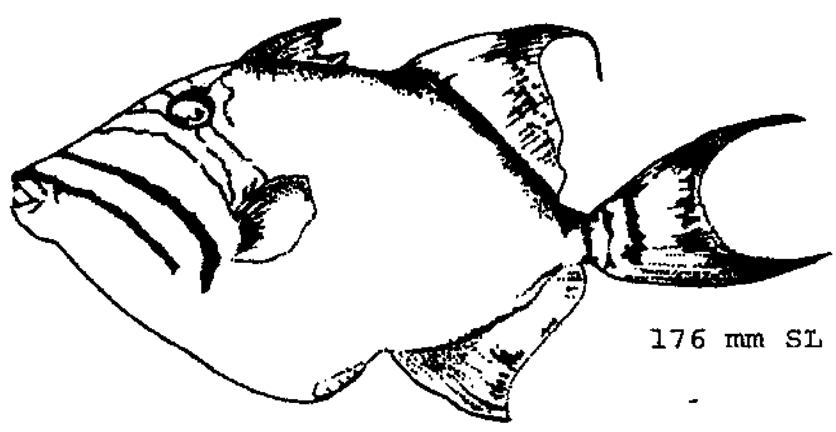
No information.

A



59.6 mm SL

B



176 mm SL

Fig. 138. *Balistes vetula,* Queen triggerfish. A. Juvenile, 59.6 mm SL. B. Juvenile, 176 mm SL. (*A, Fowler, H. W., 1945: fig. 293. B, Moore, D., 1967: fig. 2B, delineated by Tamiko Karr.*)

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Specimens described 10–70 mm.

At 10–20 mm SL, snout length 19–21% SL, increasing with size, eye diameter 15–18% SL, decreasing with size; each scale with a single spine, these spines disappearing between 25 and 40 mm SL.[13]

Pigmentation: Below 50 mm SL, with broken, dark lines running along some of the anterodorsal posteroventral diagonal rows of scales on sides; translucent dorsal, anal and caudal fin membranes; often the two broad bands which are present above the jaw on larger specimens are indistinct in small juveniles; on live or fresh specimens, the dark bands and reticulations are blue;[13] at 70 mm with all stripes about head and body same as adult.[4]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Stephanolepis hispidus (Linnaeus), Planehead filefish

ADULTS

D. II, 29–35;[1] A. 28[5]–35;[1,3,13] C. 12[10,23,28]–13,[23] 6+6;[28] P. I (*rudimentary at larger sizes*),[1] 12–15;[23] V. *represented by a single, moveable spine;*[1] vertebrae 19, 7+12;[28] gill rakers 30–41;[3] teeth incisor-like, upper jaw with 2 series, 6 in outer row, 4 in inner row, lower jaw teeth uniserial, 6 in the series.[6]

Body proportions as percent SL or HL: Depth 43.3–65.8 SL; head length 29.5–41.4 SL; snout length 14.4–27.5 SL;[1] eye 6.1[2]–17.1 SL[1] or about 25 HL.[6]

Body rhomboidal, caudal peduncle short,[10] strongly laterally compressed;[7,10] head triangular,[6] upper and lower profiles nearly straight,[6,7] eye near dorsal profile;[10] mouth small, terminal,[6] non-protractile.[10] *Scales with 1–8* close-set spinules (progressively more in larger individuals); each spinule branched many times in larger individuals. Lateral line in cephalic region with 3 branches, one under the eye, one to gular region and one to spinous dorsal, on side of body undulating, high over pectoral, dropping down to a mid-lateral position over anal fin and on caudal peduncle.[10] First dorsal spine over posterior

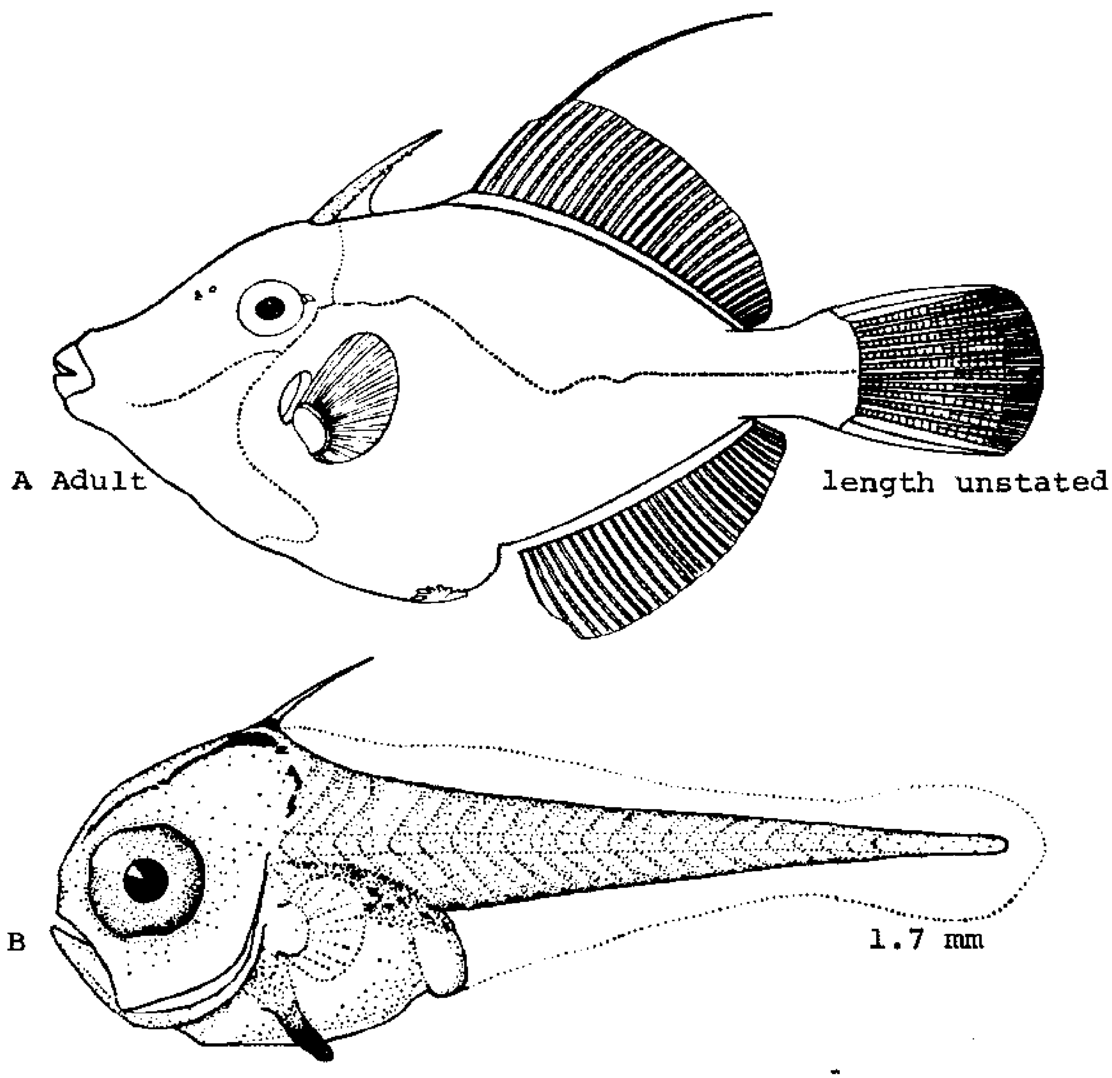

Fig. 139. ***Stephanolepis hispidus***, Planehead filefish. A. Adult, length unstated. B. Larva, 1.7 mm. Dorsal spine already well formed. (*A, Sanzo, L., 1930: fig. 11. B, Hildebrand, S. F., and L. E. Cable, 1930: fig. 98. Fig. A reversed.*)

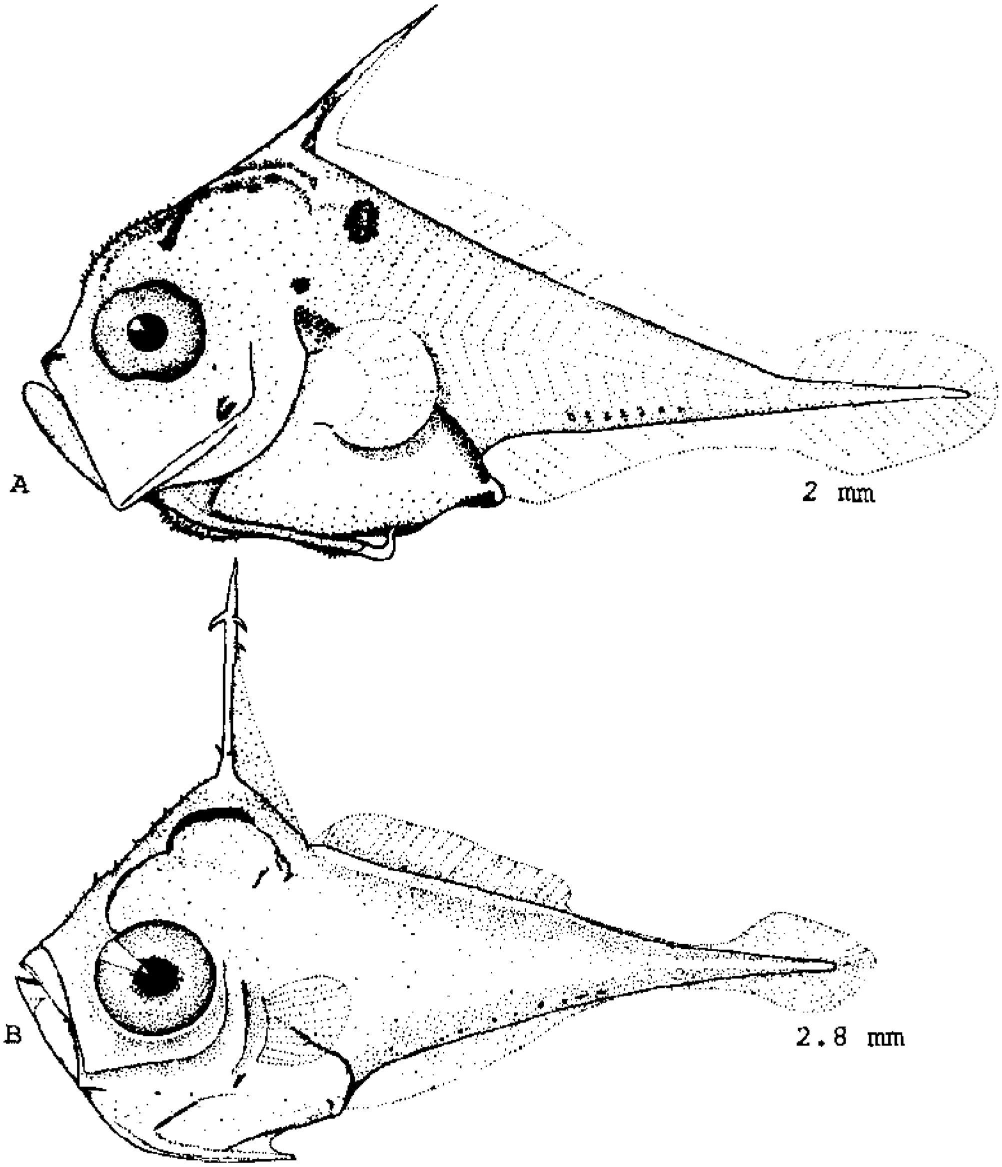

Fig. 140. ***Stephanolepis hispidus,*** Planehead filefish. A. Larva, 2 mm, fin rays forming in finfold; branchiostegal rays formed. B. Larva, 2.8 mm, barbs forming on dorsal spine, finfold broken up but no flexion. (***A, B, Hildebrand, S. F., and L. E. Cable, 1930:*** *figs. 99, 100.*)

part of eye;[1,6,10] males with first dorsal ray elongated;[1] soft dorsal fin inserted at about mid-body[6] a little in advance of anus; anal fin insertion a little behind insertion of soft dorsal fin;[10] pectoral rounded, moderate.[6,10]

Pigmentation: Color variable, from turtlegrass, individuals are mottled green; from sargassum weed, pattern of brown is common; over sand they are almost uniform pale gray; and in an aquarium with a slate bottom, very dark, color changes are rapid.[5]

Maximum length: To 254 mm.[6,7,13,14,15,18]

DISTRIBUTION AND ECOLOGY

Range: Both sides of the Atlantic, Halifax, Nova Scotia to Brazil in western Atlantic,[6,15,18] all of the Gulf of Mexico, also Bermuda.[2]

Area distribution: New Jersey[4,8,17] and lower Chesapeake Bay.[7,23,25]

Habitat and movements: Adults—pelagic, around floating plants and debris,[18] sandy or rocky areas,[2] reefs,[16] most abundant in clear water and around vegetation;[26] leave inshore areas in the winter;[18] 11[20]–42.9 ppt salinity,[11] most common over 25 ppt;[26] 10.0–38.8 C;[11] inshore to 44 m depth;[21] mostly near shore.[9]

Larvae—newly hatched, near bottom, larger ones at surface,[18] in sargassum mats.[27]

Juveniles—pelagic,[1,22] among sargassum weed[2,5,12,14,15,27] or other floating algae,[15] inshore on grass flats,[5,14,18] larger ones on beaches;[24] leave shore zone in winter;[18] 16.5–38.8 ppt salinity;[19] 10.0–31.5 C;[24] at surface;[22] over entire continental shelf[1,28] and in open ocean.[1]

SPAWNING

Location: Probably occurs at sea.[18]

Season: Small juveniles present year round along southern U.S. coast[22] indicating prolonged spawning season (FDM).

EGGS

Probably pelagic;[8] unfertilized egg about 0.7 mm; very adhesive; pale green; a group of small oil droplets on

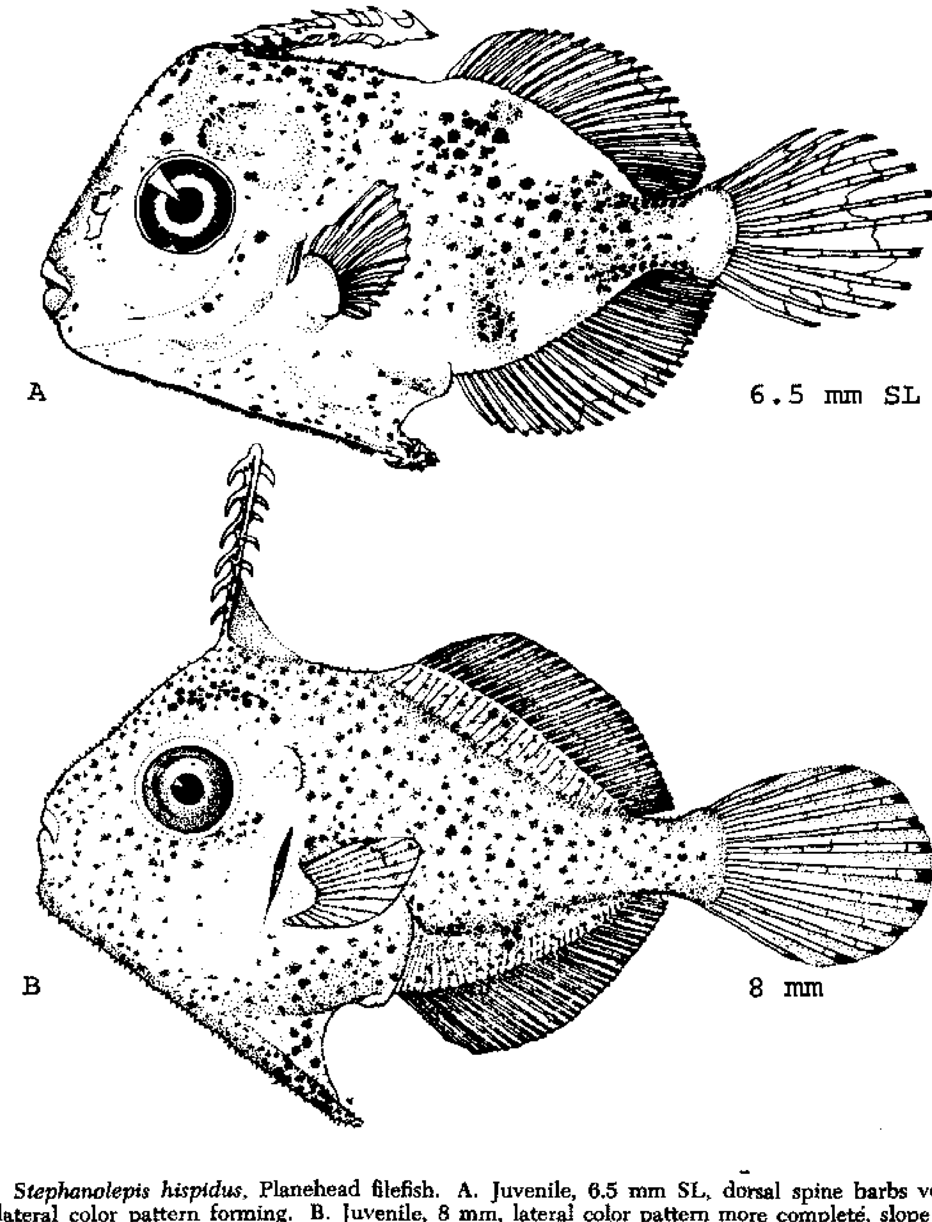

Fig. 141. *Stephanolepis hispidus*, Planehead filefish. A. Juvenile, 6.5 mm SL, dorsal spine barbs very well developed, lateral color pattern forming. B. Juvenile, 8 mm, lateral color pattern more complete, slope of forehead less steep. (*A, Berry, F. H., and L. E. Vogele, 1961: fig. 16. B, Hildebrand, S. F., and L. E. Cable, 1930: fig. 101.*)

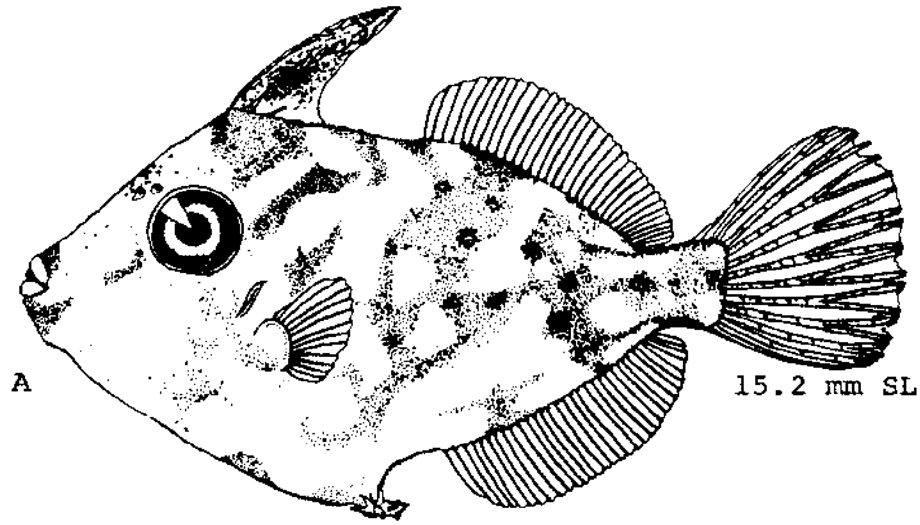

Fig. 142. *Stephanolepis hispidus*, Planehead filefish. A. Juvenile, 15.2 mm SL, dorsal spine barbs less developed. (*A, Berry, F. H., and L. E. Vogele, 1961: fig. 17.*)

one side of the yolk.[29]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

Reported at 1.7 mm,[24] possibly misidentified *Monacanthus ciliatus* or *Stephanolepis setifer* (FHB).

Body robust with a long pointed tail; head blunt anteriorly; dorsal spine present; pectoral fin buds present; pelvic fin buds present; vertical finfold continuous.

Pigmentation: Dark pigment present on head, extending along upper surface to base of dorsal spine, from there along upper margin of abdomen to vent, then as a row of somewhat larger dots along the ventral edge to tip of tail.[18]

LARVAE

From about 1.7 mm to 8 [8] mm, specimens between 1.7 mm and 2.8 mm may be misidentified *Monacanthus ciliatus* and *Stephanolepis setifer* (FHB).

Body deep, becoming deeper at 3 mm, by 5 mm much like adult body shape; mouth small and terminal at 3 mm. Dorsal spine developed at 1.7 mm,[8] high and prominent with a few barbs at 3 mm; traces of dorsal rays at 3 mm, well formed at 5 mm; anal fin with traces of rays at 3 mm, rays well formed at 5 mm; [18] pelvics represented by buds at 1.7 mm, do not develop beyond this point; finfold continuous at 2.0 mm.[8] Scales represented by small, forming prickles at 3 mm, skin generally beset with prickles afterward.[18]

Pigmentation: At 3 mm dark pigment on head extending onto back; ventral periphery usually slightly pigmented, pigment also on side above and behind the abdomen. At 5 mm, color pattern principally dark dots scattered over body.[18]

JUVENILES

To 60 [19] or 75 mm.[18]

Body shape same as adult at 15 mm; snout shorter and blunter than adult, as fish grows, snout elongates, continuing even after 75 mm; dorsal spine barbs on both anterior and posterior margins of spine, barbs proportionally smaller at 15 mm, disappearing by 40–50 mm; anal, caudal and pectoral fins well developed and shaped like adult fins at 8 mm; pelvic spine largely free and prickly at 8 mm, attached to abdomen by a membranous flap at 15 mm, this flap increasing with size, reaching tip of spine by 75 mm.[18]

Pigmentation: Spots with dark centers everywhere on body except behind eye and around gill opening. At 15 mm, brownish spots with dark centers everywhere on head and body; some dark marbling evident; fins almost colorless.[18]

GROWTH

No information.

AGE AND SIZE AT MATURITY

Females with eggs at 81 mm.[1]

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Lactophrys polygonia
Lactophrys quadricornis
Lactophrys trigonus
Lactophrys triqueter

boxfishes
Ostraciidae

FAMILY OSTRACIIDAE

This family is primarily of tropical and subtropical distribution with individual specimens straying into the area, especially during summer months. There is documentation showing breeding of these species as far north as the Atlantic coast of Florida and probably most of the specimens are either ultimately from Florida or the Bahamas, having been transported northward by the Gulf Stream. Small juveniles or late larvae cannot be mistaken for any other forms which occur locally, except perhaps diodontids, and then only if examination has been superficial. Small larvae and yolk-sac larvae superficially resemble tetraodontid larvae, to which the ostraciids seem to be related.

Lactophrys polygonia (Poey), Honeycomb cowfish

ADULTS

D. 10;[1,4] A. 10;[1] C. 10,[1,4] 5+5;[4] P. 10–12/11–12,[2] 12/12 in 82% of specimens, rudimentary upper ray not counted;[1] vertebrae 18, 14+4, first 5 fused to each other and to basioccipital;[2] gill rakers 11–14.[3]

Body proportions: Carapace width 58.8–71.4% depth.[3]

Carapace usually without terminal spines behind dorsal and anal fins,[1,2,5] angle of snout profile 64–78°. Scales represented by bony scutes with granular surfaces.[2] Caudal fin rounded.[1,2,3]

Pigmentation: Olivaceous,[3] most hexagonal scutes on lateral surfaces of carapace with pale borders surrounding a dark, more or less hexagonal ring which in turn surrounds a pale central area of the scute;[1] these dark rings incomplete dorsally;[1,3] on cheeks a reticulate pattern of irregularly anastomosed rings;[1] larger specimens with irregular dark markings inside the dark rings;[1,3] a wash of purplish blue, especially on sides and ventrally.[3]

Maximum length: To 483 mm.[5]

DISTRIBUTION AND ECOLOGY

Range: New Jersey to Brazil,[3,5] including the Central American coast;[5] also known from Bermuda, the Bahamas and the West Indies;[1] not reported from the Gulf of Mexico.[1,3]

Area distribution: New Jersey.[1,3]

Habitat and movements: Adults—mostly around rocky and coral reefs;[2,3] reported down to 77 m.[5]

Larvae—no information.

Juveniles—no information.

SPAWNING

Ripe female taken in July.[6]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Below 70 mm SL, adult pattern not developed, ventral surface spotted;[1] small specimens, 15–23 mm SL, yellow with small, round, black spots.[5]

GROWTH

No information.

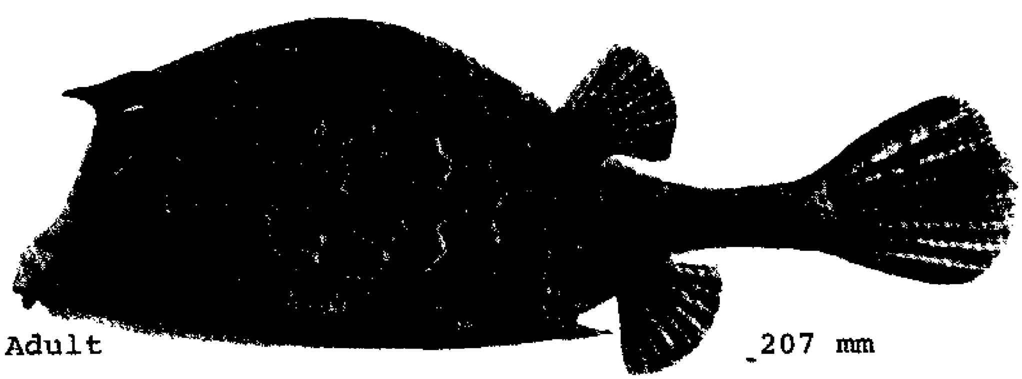

Fig. 143. *Lactophrys polygonia*, Honeycomb cowfish. A. Adult, 207 mm. (*A, Böhlke, J. E., and C. C. G. Chaplin, 1968: 680. © Academy of Natural Sciences of Philadelphia. Used with permission of author and publisher.*)

AGE AND SIZE AT MATURITY

No information.

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Lactophrys quadricornis (Linnaeus), Scrawled cowfish

ADULTS

D. 9–10,[6] 90% with 10;[17] A. 10;[6,10,17] C. 10,[17] 5+5;[13] P. usually 11 [1,17] not counting upper rudimentary ray;[17] vertebrae 19, 14+5, first 5 fused to each other and to the basioccipital;[15,18] gill rakers 13–17.[1]

Body proportions as percent TL or HL: Head length 32.2–34.5 TL; eye 41.7–47.6 HL.[6] Carapace width 52.6–62.5% depth.[1]

Carapace triangular in cross-section, low ridge on each side of back, dorsal ridge elevated, ventral surface nearly flat; head with spines directed forward over each eye,[10] angle of snout profile 66–85°.[15] Scales represented by bony scutes with granular surfaces.[17] Caudal fin rounded to truncate.[1,17]

Pigmentation: Background color brownish, greenish,[6,7] yellowish,[1,6] bluish [6] or grayish;[7] always at least some indication of 2, usually 3 or occasionally 4, more or less horizontal, dark stripes on cheek, uppermost just above eye, lowermost just above lower end of opercular opening. Below the lowermost stripe begins a dark stripe, which borders the ventrolateral edge of the carapace from the cheek to at least the base of the ventrolateral carapace spine; another dark stripe present on dorsal crest of carapace from posterior portion of interorbital region to anterior edge of opening in carapace for dorsal fin; rest of color pattern variable; dark spots, blotches and irregularly wavy stripes; geographic variation in amount and size of spotting and regularity of spots.[17]

Maximum length: To 483 mm.[7]

DISTRIBUTION AND ECOLOGY

Range: Both sides of Atlantic, in eastern Atlantic, from Guinea Coast to Cape of Good Hope; in western Atlantic, common from North Carolina to Brazil,[10] strays to Massachusetts; also in Bermuda [1,6,7] and Gulf of Mexico.[7,10]

Area distribution: New Jersey,[8] Atlantic coast of Maryland and Chesapeake Bay.[10]

Habitat and movements: Adults—grass beds,[1,5,11,16] over sand or mud,[15] occasionally over open reefs;[14] 15.4 [3]–37.9 ppt salinity,[3,4] mostly above 30 ppt;[12] 10.0–33.6 C,[3] however, reported to be sluggish at 19.4 C;[9] inshore to 73 m.[7,19]

Larvae—in lab, lie on bottom or float inverted while yolk-sac larvae.[2]

Juveniles—nearshore;[12] associated with grass beds; 25.0–35.5 ppt salinity; 10.0–34.9 C.[21]

SPAWNING

Contradictory reports, but probably both in bays or at least nearshore [11] and also offshore;[12] eggs have definitely been found inshore.[16]

Season: Occurs year round with peaks of egg abundance in early months of the year [20] or in late spring and early summer.[16]

EGGS

Location: Pelagic,[2,16] do not float well in lower salinity water, or until thoroughly waterhardened,[2] also sink 1–2 hours before hatching.[16]

Fertilized eggs: Spherical;[2] heavily pigmented, either green or white;[16] 1.40–1.60 mm, mean of 1.46 mm; nonadhesive;[2] single oil droplet [2,16] averaging 0.15 mm diameter, amber.[2]

EGG DEVELOPMENT

Heart beating at 48 hours at an unstated temperature;[16] hatch in 48 hours at 27.5 C.[2]

YOLK-SAC LARVAE

Hatch at 6 mm, shrink down to 5 mm, yolk absorbed by 5 mm.[2]

Body short and chunky.[2]

LARVAE

Yolk absorbed at 5 mm (114 hours after hatching), juvenile by 10 mm TL.[2]

At 8.2 mm SL, all vertebrae separate.[18]

Pigmentation: Heavy pigmentation where adult carapace will be,[2] characteristically with white spots.[16]

JUVENILES

10 mm TL to at least 80 or 90 mm.[2]

At 15.3 mm SL, first 2 vertebrae with centra fused to each other and basioccipital; at 25.0 mm SL, centra of first 5 vertebrae fused to each other and basioccipital; at 77.7 mm SL first 5 vertebrae completely fused to each other and basioccipital.[18] Frontal spines well developed at 35 mm.[14]

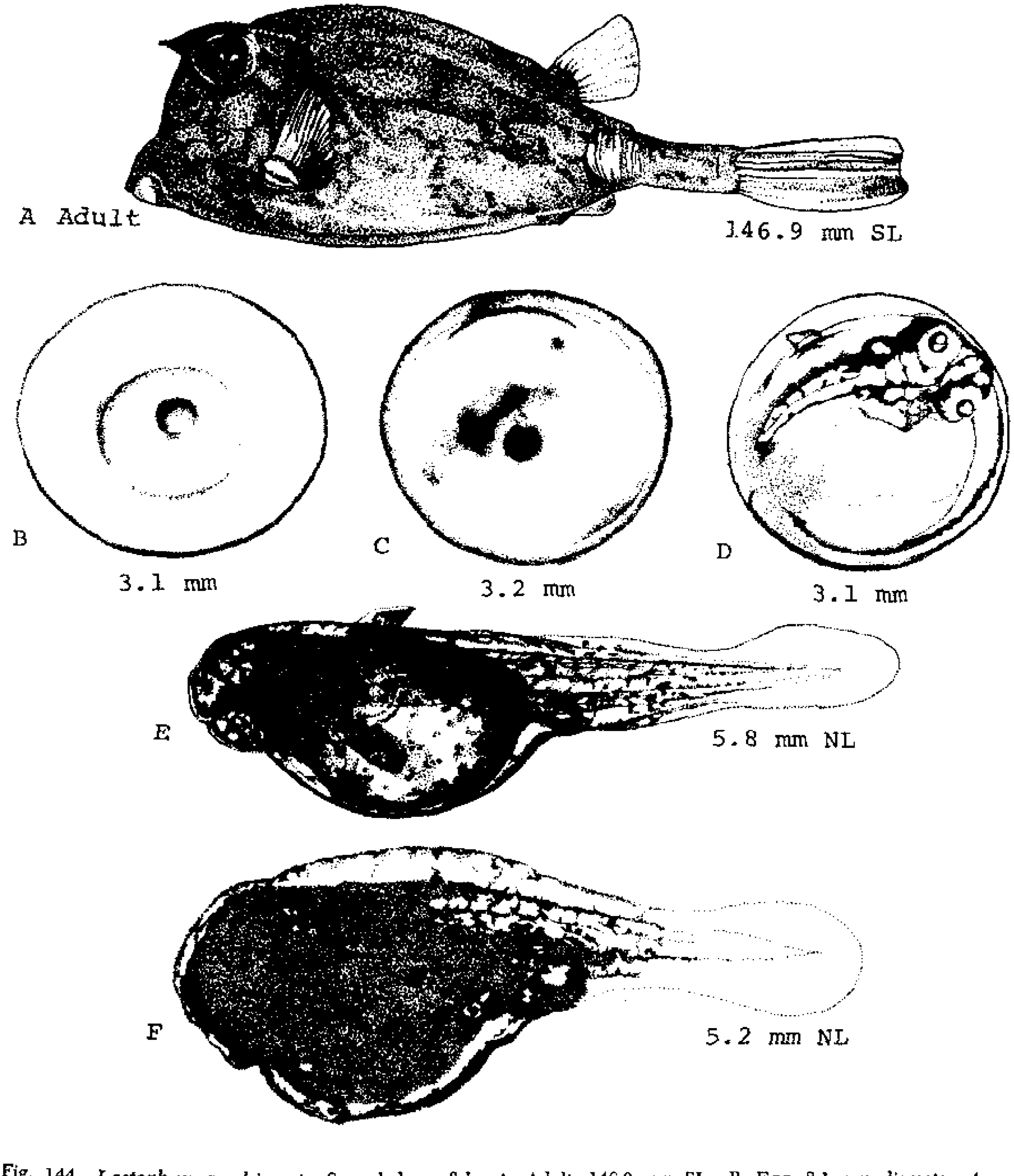

Fig. 144. ***Lactophrys quadricornis***, Scrawled cowfish. A. Adult, 146.9 mm SL. B. Egg, 3.1 mm diameter, 4 hours after fertilization. C. Egg, 3.2 mm diameter, somewhat older than that in previous illustration. D. Egg, 3.1 mm diameter, near hatching, 40 hours after fertilization. E. Yolk-sac larva, 5.8 mm NL, shortly after hatching. F. Yolk-sac larva, 5.2 mm NL, 48 hours after hatching. *(A, Tyler, J. C., 1965: fig. 10, delineated by Donna Jean Davis. B-F, Breder, C. M., Jr., and E. Clark, 1947: pl. 14, eggs and 5.2 mm yolk-sac larva delineated by Tamiko Karr, 5.8 mm yolk-sac larva delineated by Joan Ellis.)*

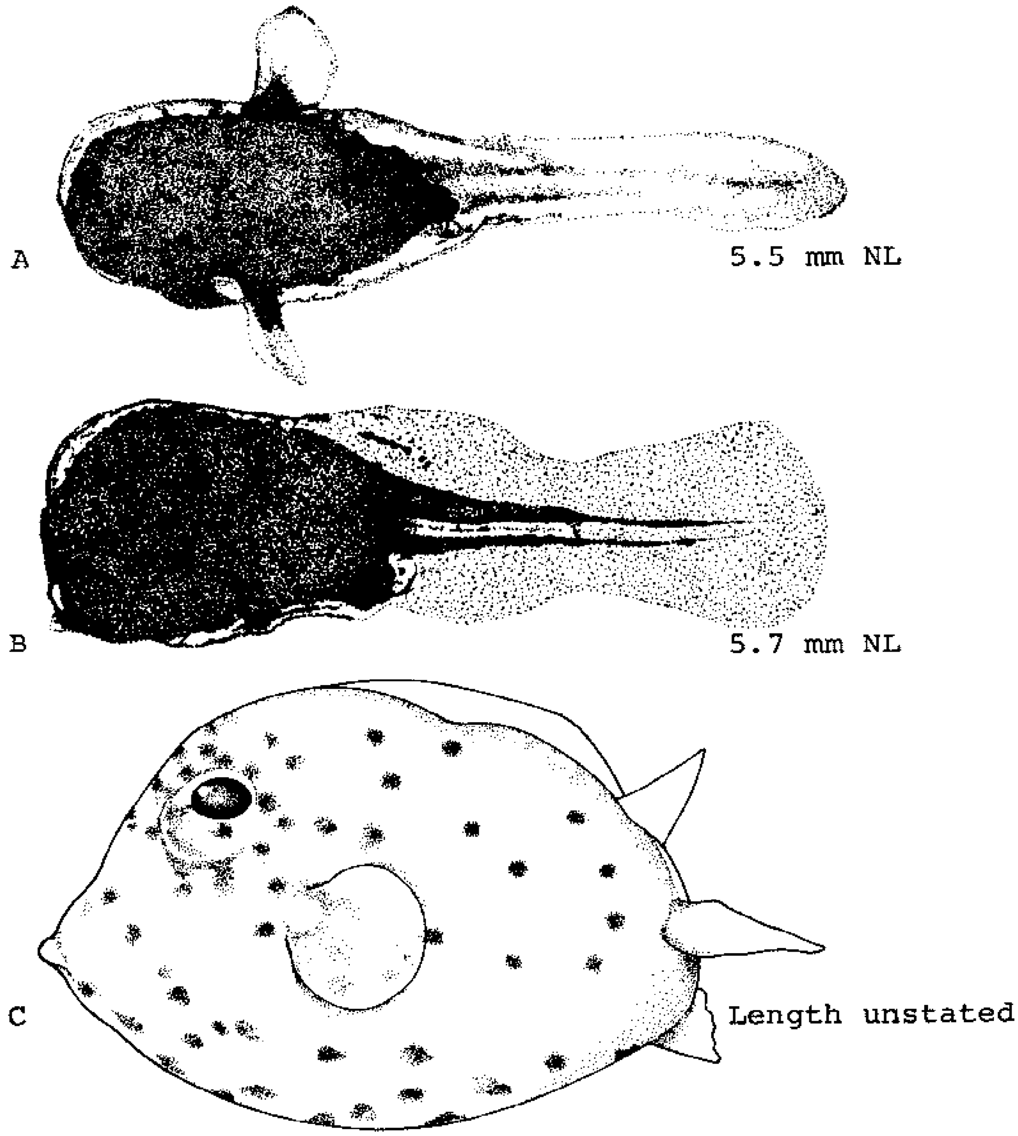

Fig. 145. *Lactophrys quadricornis*, Scrawled cowfish. A. Larva, 5.5 mm NL, dorsal view, 72 hours after hatching. B. Larva, 5.7 mm NL, 114 hours after hatching. C. Juvenile, length unstated, background color tan, dark brown spots. (*A, B, Breder, C. M., Jr., and E. Clark, 1947: pl. 14; delineated by Tamiko Karr. C, Walls, J. G., 1975: fig. 489b; delineated by Elizabeth Ray Peters. © TFH Publications. Used with permission of author and publisher. Printed reversed.*)

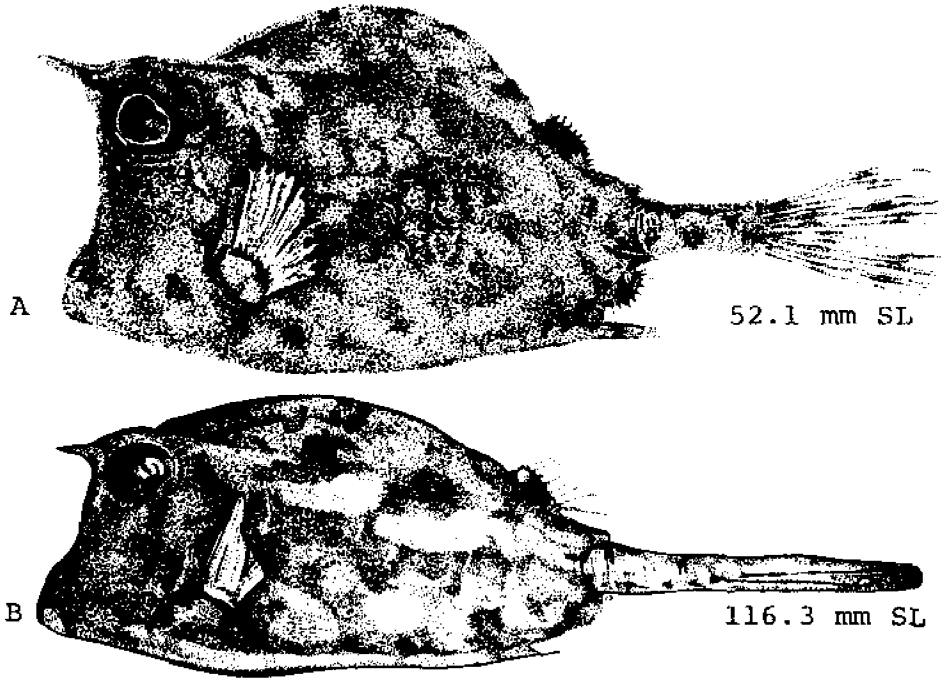

Fig. 146. *Lactophrys quadricornis*, Scrawled cowfish. A. Juvenile, 52.1 mm SL. B. Juvenile, 116.3 mm SL. Body form approaching that of adult. *(A, B, Tyler, J. C., 1965: figs. 12, 10, fig. 12 delineated by Tamiko Karr, fig. 10 delineated by Donna Jean Davis.)*

Pigmentation: Below 70 mm SL, covered with dark spots, at 70 mm assumes adult color pattern;[17] a specimen of unstated size figured by Walls is tan with scattered roundish dark spots.[19]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Lactophrys trigonus (Linnaeus), Trunkfish

ADULTS

D. 9[6]–10;[7,10] A. 9[6]–10;[7,10] C. 10;[10] P. 11–13 usually, 12;[2] vertebrae, 15+3, centra of first 5 vertebrae fused to each other and basioccipital;[12] gill rakers 17–18.[2]

Body proportions as percent TL: Head 26;[6,7] depth 35.7–38.5;[6] width of carapace 90.9% depth in adults.[2]

Carapace triangular in cross-section,[1,6,19] carapace closed behind dorsal fin;[1,6] mouth very small and terminal.[6] Caudal fin emarginate.[2]

Pigmentation: Color highly variable,[1] usually olivaceous[1,2,7] with faint blue[7] or white diffuse spots; two areas with hexagonal plates dark edged, forming chain-like markings, one above and behind pectoral region and the other about halfway from gill opening to posterior end of carapace; large individuals lose pale spots and chain marks, and develop as a "terminal adult color pattern" an irregular reticulate pattern over carapace and caudal peduncle.[1,2,13]

Maximum length: To 457 mm.[1,2]

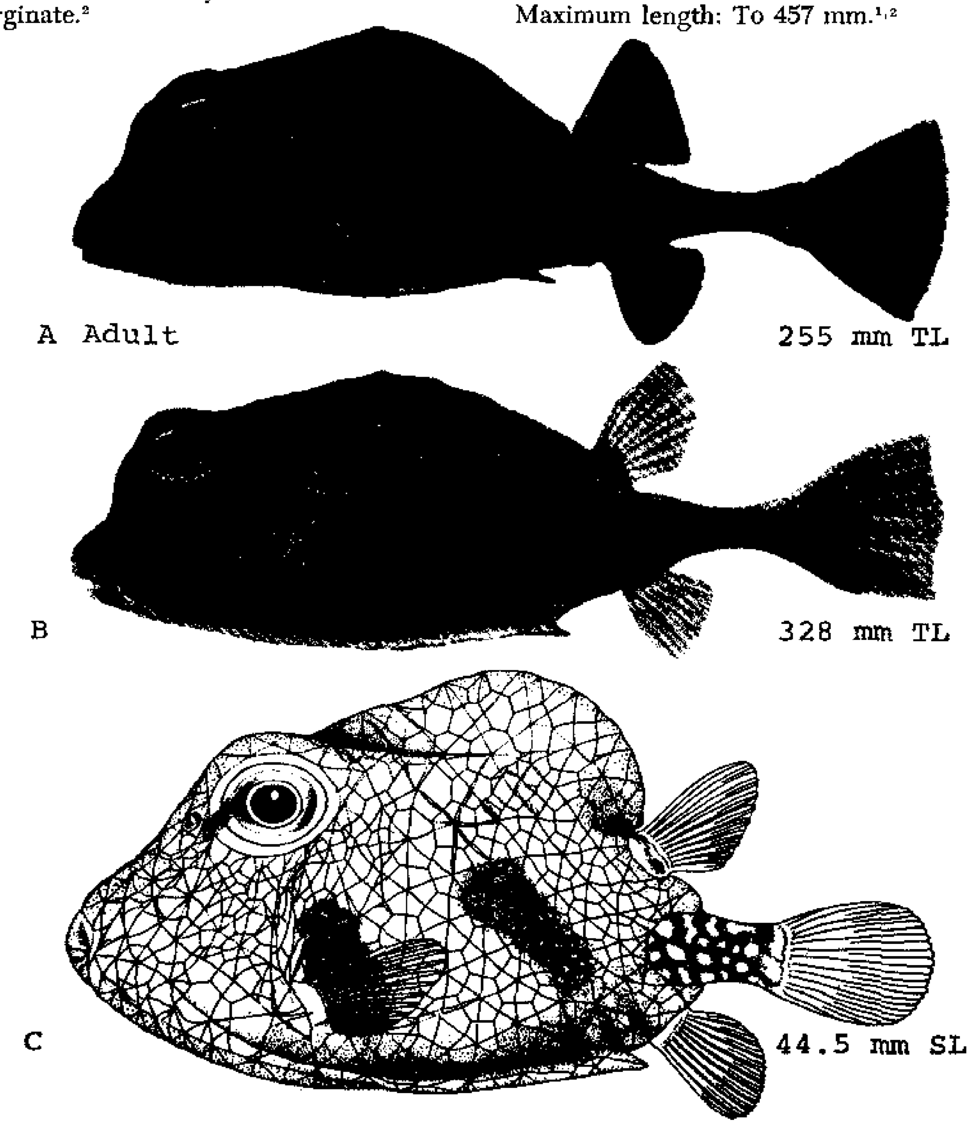

Fig. 147. *Lactophrys trigonus*, Trunkfish. A. Adult, 255 mm TL, most common color pattern. B. Adult, 328 mm TL, most extreme reticulated color pattern. C. Juvenile, 44.5 mm SL. (*A-B, Böhlke, J. E., and C. C. G. Chaplin, 1968: 683. © Academy of Natural Sciences of Philadelphia. Used with permission of authors and publisher. C, Fowler, H. W., 1945: fig. 309.*)

DISTRIBUTION AND ECOLOGY

Range: West Indies, common as far north as the Florida Keys and Bermuda, occasionally northward in the Gulf Stream to Massachusetts.[8]

Area distribution: New Jersey,[3,5] lower Chesapeake Bay.[6,10]

Habitat and movements: Adults—seagrass habitats,[2] down to 37 m.[1]

Larvae—no information.

Juveniles—grass flats [4,8,11] or under *Sargassum;* [8] 21.1–36.8 ppt salinity; 27.0–31.0 C.[9]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Reported from 6–102 mm.[9]

Body proportions, head 50% TL, depth 77% TL; eye 25% HL.[6]

Body about 4 angled in cross-section, with a prominent dorsomedial ridge.[6] Caudal fin rounded.[2]

Pigmentation: In preservative, uniformly brownish, fins translucent, plain.[6]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Lactophrys triqueter (Linnaeus), Smooth trunkfish

ADULTS

D. 10;[3,4] A. 9–10;[4] P. 12, not counting rudimentary upper ray;[5] 9–10 bony plates in horizontal series from gill opening to tail;[9] vertebrae 15+3, first five with centra fused to each other and basioccipital;[1] gill rakers 8–9.[5]

Body proportions as percent HL or SL: Head length 23.2[4]–25 SL;[10] maximum depth 41.1–43.3 SL;[4] snout length 71.4 HL;[1] eye 41.7 HL[3] or 8.3–10.0 SL.[4] Carapace width 90.9 maximum body depth.[5]

Body triangular in cross-section, dorsomedial ridge strongly arched, carapace closed behind dorsal fin;[9] head profile concave.[10] Scales represented on trunk by bony hexagonal plates with surface tubercles, fused to form a carapace.[9]

Pigmentation: Body coloration changeable, paler over sand, more olivaceous among gorgonians;[7] ground color brownish, greenish,[3] yellowish green[4] or blackish;[5] roundish light spots present,[4] these being white[5] or greenish blue;[3] bases of dorsal, caudal and anal fins

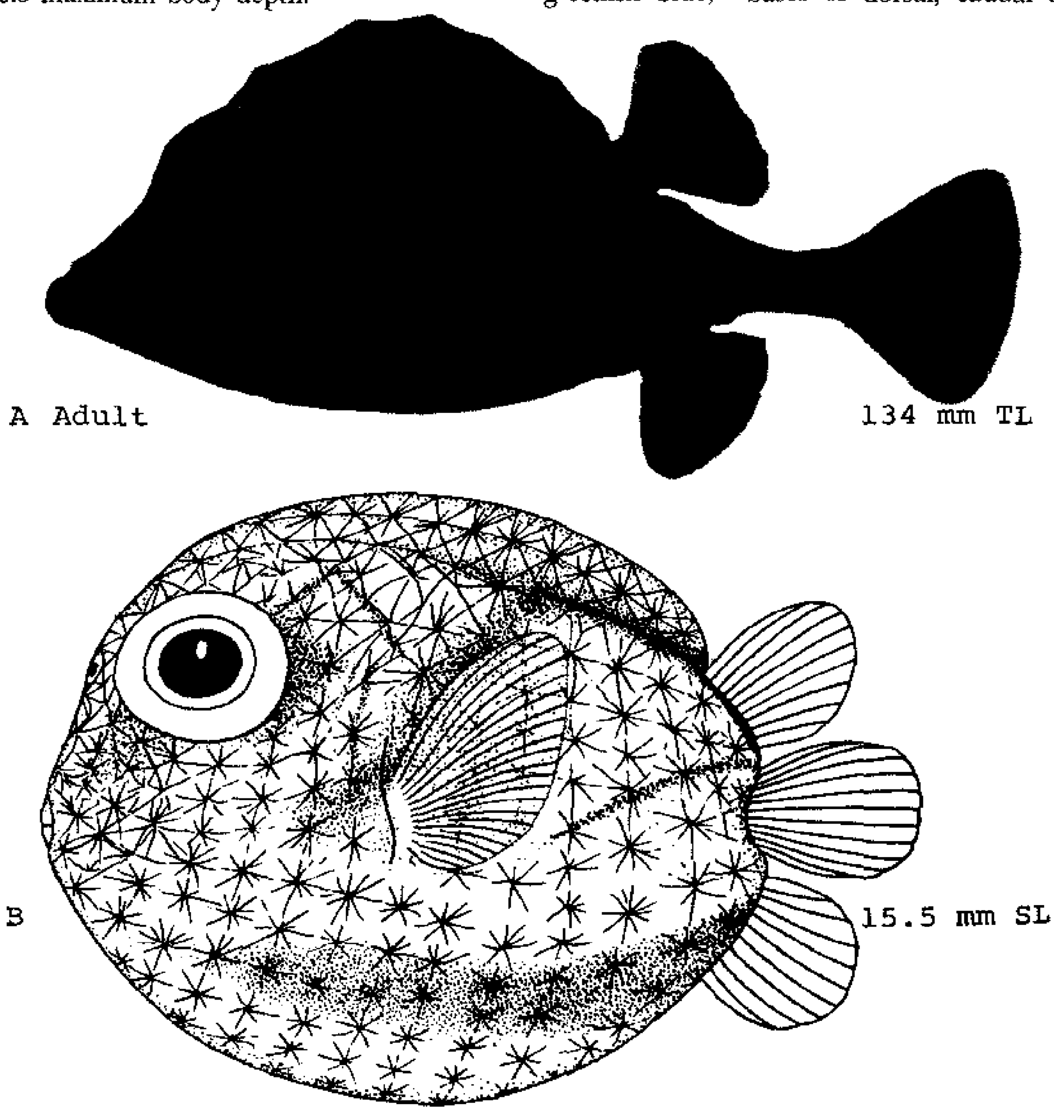

Fig. 148. *Lactophrys triqueter*, Smooth trunkfish. A. Adult, 134 mm TL. B. Juvenile, 15.5 mm SL. (*A, Böhlke, J. E., and C. C. G. Chaplin, 1968: 681. © Academy of Natural Sciences of Philadelphia, used with permission of authors and publisher. B, Fowler, H. W., 1945: fig. 286.*)

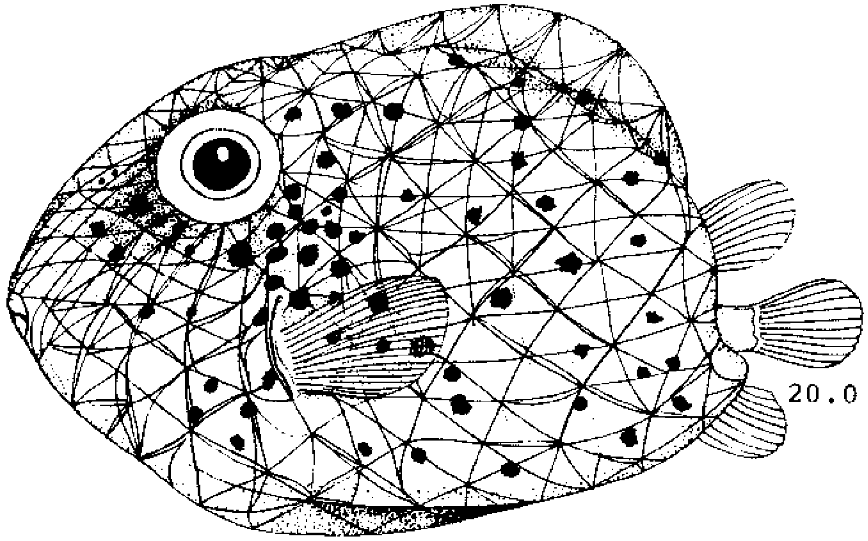

Fig. 149. *Lactophrys triqueter,* Smooth trunkfish. A. Juvenile, 20.0 mm SL. (*Fowler, H. W., 1945: fig. 285.*)

black,[3,4,5] fins otherwise plain or bright yellow[3] except for posterior margin of caudal fin which may be black[4] with a narrow white edge.[5]

Maximum length: 305 mm.[5,9]

DISTRIBUTION AND ECOLOGY

Range: Bermuda and Massachusetts to Rio de Janeiro[4,5] and northern Gulf of Mexico.[4]

Area distribution: New Jersey.[2,6]

Habitat and movements: Adults—coral or rocky reefs,[4,5,7] over sand or algal flats;[7] occur down to 6 m.[8]

Larvae—no information.

Juveniles—no information.

SPAWNING

Peaks in January, February or March, no spawning between August and December.[11]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Figured by Fowler but without written description.[2] Scale plates with striae radiating from center of each plate.[9]

Pigmentation: Color light green with numerous dark greenish blue spots on side and below.[10]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Lagocephalus laevigatus
Sphoeroides maculatus
Sphoeroides pachygaster
Sphoeroides spengleri
Sphoeroides testudineus

puffers
Tetraodontidae

FAMILY TETRAODONTIDAE

This family is primarily tropical in distribution with only five species occurring in the area. Of these, only *Sphoeroides maculatus* breeds in the area, though adults and juveniles of *Lagocephalus laevigatus* and *Sphoeroides spengleri* may be encountered with some frequency. This family shares with its near relatives, the diodontids, the ability to inflate, probably for protection from predation. Most species in the family are shallow water marine and estuarine species, but some are pelagic (e.g., *Lagocephalus* sps.) or deep water forms (e.g., *Sphoeroides pachygaster*) while some tropical species are secondary freshwater forms. Tetraodontid eggs, where described, are demersal and most are adhesive.

Lagocephalus laevigatus (Linnaeus), Smooth puffer

ADULTS

D. 13–14,[7,14] rarely 15;[7] A. 12–13;[1,7,15] C. 11,[7,15] 5+6;[16] P. 15–19, *usually* 17 *or* 18;[7] *vertebrae* 19, 8+11.[15]

Body proportions as percent SL or HL: Head length 29.4[7]–39.4 SL, decreasing with length;[1] predorsal length 66 SL;[7] eye 20.8[4]–25.0 HL or 7.4–9.4 SL; snout 50.0–58.8 HL.[7]

Body elongate, somewhat deeper than broad,[1] tapering gradually posteriorly, abdomen pendulous,[14] lower edge of body with a longitudinal fold or keel; head long, snout blunt; mouth small, nearly terminal.[4] Teeth represented by a beak-like plate, with a median suture.[7] Scales 3-rooted spines, well separated[6] and located on venter only (RLS); lateral line present, branched anteriorly. Origin of dorsal fin somewhat in advance of that of anal fin; pectoral fins short and broad; caudal fin deeply emarginate,[4] upper lobe may be longer than lower.

Pigmentation: Dorsum dark green,[7] olive-brown,[2] greenish gray[1] or brownish gray[7] becoming dusky on caudal peduncle;[2] sides silvery,[2,7] gray in preservative;[7] belly white[1,2,7] or with a yellow tinge;[2] may have 5–8 irregular bars on dorsum; often with black pigmentation anterior to pectoral fin base;[7] lips pale brownish yellow;[2] caudal fin heavily pigmented except its distal extremities; pectoral base and lower third of pectoral fin often pigmented;[7] anal fin transparent;[1] eyes slaty, iris with a ring of greenish yellow.[2]

Maximum length: 610 mm.[4,10]

DISTRIBUTION AND ECOLOGY

Distribution: Both sides of Atlantic, in eastern Atlantic from northern Africa to Angola; in western Atlantic from New England to Argentina[7] including Gulf of Mexico;[1] rare north of Cape Hatteras.[4,10]

Area distribution: New Jersey;[2,11] Delaware Bay;[3] Atlantic coasts of Maryland[14] and Virginia;[16] and Chesapeake Bay south of the Bay Bridge.[5]

Habitat and movements: Adults—pelagic and inshore habitats, sometimes even in shallow estuaries,[7] sandy or rocky areas;[1] 24.9–37.9 ppt salinity; 15.2–27.0 C;[9] surface[7] to 64 m.[13]

Larvae—no information.

Juveniles—no information.

SPAWNING

Thought to occur offshore;[9] possibly in the fall in Texas waters.[9]

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Specimens described 28.6–73 mm.

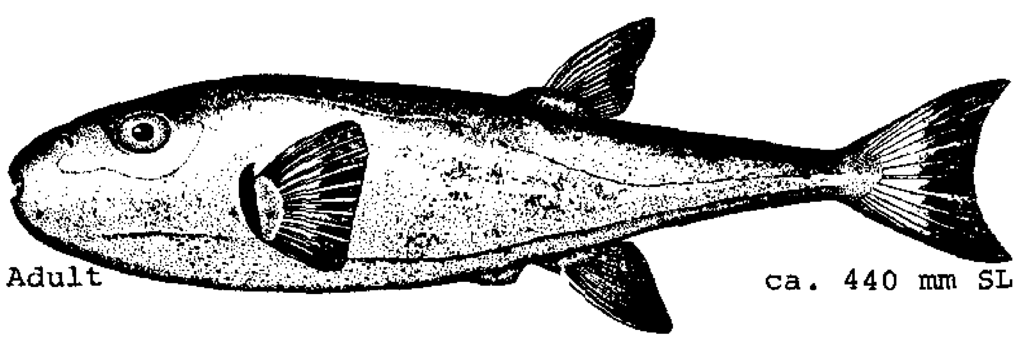

Fig. 150. *Lagocephalus laevigatus*, Smooth puffer. A. Adult, ca. 440 mm. (*A, Jordan, D. S., and B. W. Evermann, 1896–1900: fig. 642.*)

Pigmentation: At 28.6 mm—slaty brown on back, silvery and grayish on sides, milky white below; dorsal fin dusky brown with anterior portion darker and posterior portion lighter; caudal fin slaty, tip of each lobe milky white; anal fin pale brownish; pectoral fin pale brownish, darker basally.[2]

At 60 mm—a light bar at base of caudal fin, outer rays light, rest blackish; dorsal and anal fins darker distally.[3]

GROWTH

No information.

AGE AND SIZE AT MATURITY

Mature at 200–300 mm.[7]

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Sphoeroides maculatus (Bloch and Schneider), Northern puffer

ADULTS

D. 8; A. 7; C. 11, first upper and 2 lower rays unbranched,[13] 5 + 6;[23] P. 15–16, rarely 17;[9,13] vertebrae 19, 8 + 11.[23]

Body proportions as percent SL or HL: Head 33.3–37.0 SL; snout 47.6–58.8 HL; eye 12.5–25.0 HL.[13]

Body, when not inflated, rounded, tapering from region of base of pectoral fin to a rather slender caudal peduncle;[5,17] head bluntly pointed, upper profile straight;[5] mouth terminal, very small.[5,6,17] No true teeth, plates forming beaks with cutting edges, suture on midline giving appearance of 2 incisors above and below.[5,6,17] Scales modified into prickles, stellate with 3–5 roots, on entire body from snout to anal fin origin;[9] lateral line very feebly developed.[6] Dorsal fin opposite posterior edge of anal opening, slightly anterior to anal fin origin; caudal fin truncate or slightly rounded;[5,6,13] pectoral fins moderate; pelvic fins absent.[5]

Pigmentation: Restricted to dorsolateral surfaces; dorsal background color gray,[9,13] dark olive green, ashy or dusky; sides greenish yellow to orange fading to white belly;[17] poorly defined black spots cover dorsal surfaces and a vague dark bar traverses the interorbital region; vague dark saddle across dorsum passing through dorsal fin base; another similar saddle present on caudal peduncle; tiny jet-black spots, about 1 mm diameter, scattered over pigmented areas, especially evident on cheeks, may be absent on individuals shorter than 100 mm SL;[9,13] sides with 5–7 or 6–8 bands or blotches,[9,13,17] usually vertical but may be diagonal, these extending from dorsum to belly white area; an intense black spot or bar at posterior axil of pectoral fin; distinct bars or spots usually absent on flanks anterior to pectoral fins; base and distal half of caudal fin may be dusky with a lighter central region, but often entire caudal fin may appear uniformly dusky; other fins devoid of pigment.[9,13]

Maximum length: To 356 mm.[5,6,17]

DISTRIBUTION AND ECOLOGY

Range: Newfoundland to southern Florida,[5,9,13,17] rare north of Cape Cod.[5,17,19]

Area distribution: New Jersey,[4,12,19] Delaware Bay;[10,21,22] Delaware;[10] Atlantic coasts of Maryland[9,10,13,20] and Virginia;[9,13] Chesapeake Bay south of Love Point, Maryland.[6]

Habitat and movements: Adults—sandy shores;[19] over sand,[20,22] silt and mud;[22] around piers,[20] in estuaries,[13] bays and open Atlantic situations;[9] move inshore in spring, winter offshore;[13,17,22] 6.7[18]–34 ppt salinity;[13] 10.0[14]–34.1 C;[18] surface to 20 m;[9] mostly nearshore[10] but occasionally offshore.[9]

Larvae—phototrophic, move to surface and float there;[5] 11–22 ppt salinity;[15] 20.0–23.0 C.[3]

Juveniles—semidemersal on smooth bottoms;[2] 11[15]–32.2 ppt salinity; 20.4–29.4 C;[14] commonly at shoreline.[2]

SPAWNING

Occurs in shoal waters near shore.[17]

Season: May to August, in New York peak occurs in June.[1]

Fecundity: 176,000 eggs in a 265 mm female.[6,17]

EGGS

Demersal,[13,19] cemented to substrate,[8,17] partly buried in sand in aquaria; may be broadcast or deposited in a circle roughly of a diameter equal to the fish's length;[7] deposited in aggregates;[8,17] spherical; transparent, area of blastoderm with a faint yellowish olive tinge;[7] diameter 0.85–0.91 mm,[7,8,19] mean diameter of 0.87 mm;[7,8] with adhesive coating diameter may be 0.95 mm; membrane finely reticulated, resembling crepe paper;[7] adhesive,[8,13,17] gelatinous covering acts as cement, large number of colorless oil droplets.[8]

EGG DEVELOPMENT

Incubation period about 112 hours at 19.4 C.[7,8]

At 19.4 C:

- 15 minutes—no noticeable change.
- 2 hours—first cleavage complete.
- 16 1/2 hours—embryo beginning differentiation.
- 24 hours—embryo quite distinct.
- 44 hours—embryo reaching more than half way around yolk.
- 70 hours—tail tip free; vertebral somites visible; movements noticed; scattered melanophores along each side; eyes quite distinct; oil droplets chiefly located in dorsal half of yolk.
- 90 hours—in addition to melanophores, red and orange chromatophores scattered along sides; anteroventral surface of yolk well covered with large, dendritic melanophores; oil globules consolidating into a smaller number of larger spheres; a few small melanophores and punctulations lo-

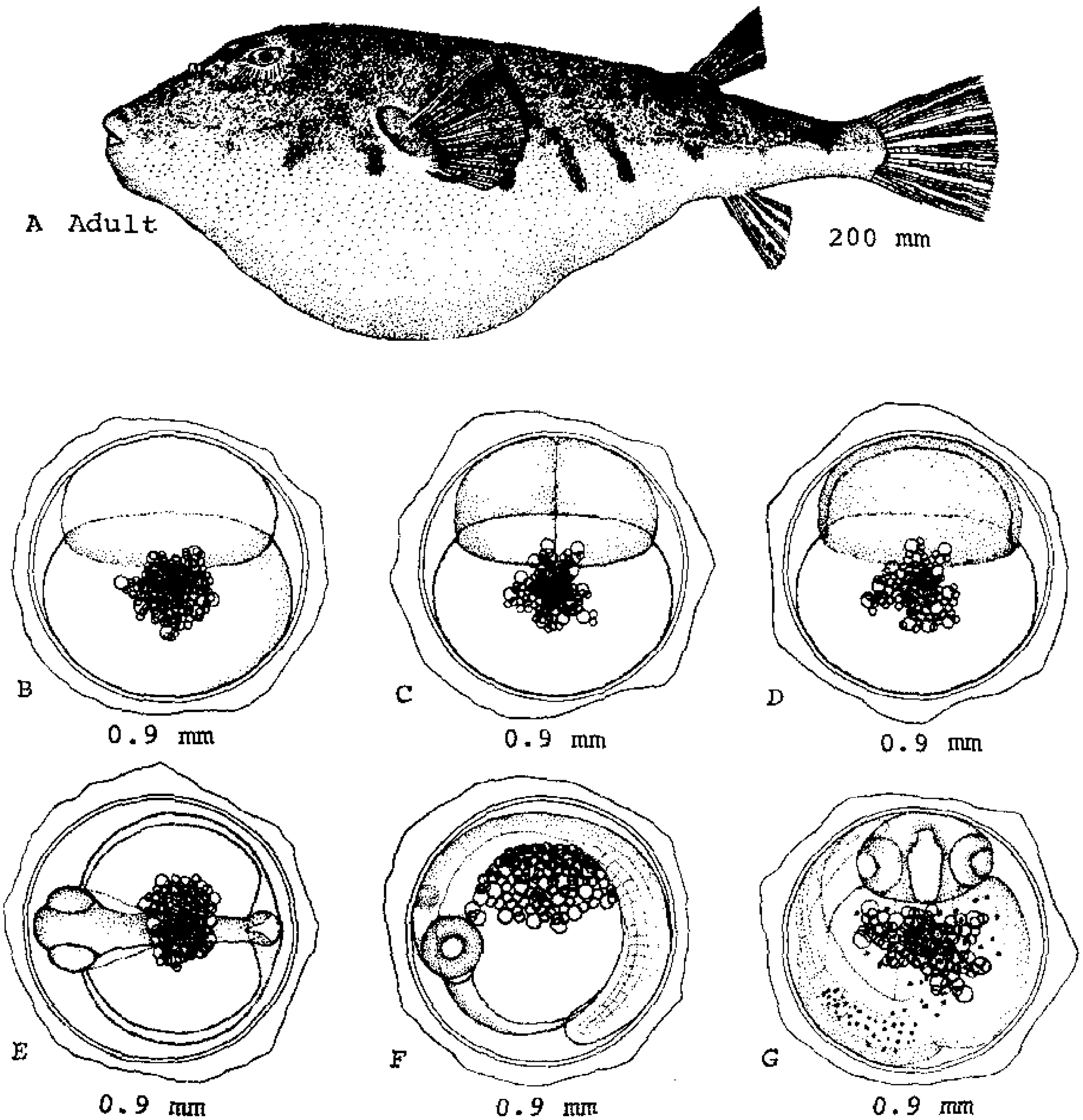

Fig. 151. Sphoeroides maculatus, Northern puffer. A. Adult, 200 mm. B. Egg, 0.9 mm diameter, unfertilized. C. Egg, 0.9 mm diameter, two-cell stage, 2 1/2 hours after fertilization. D. Egg, 0.9 mm diameter, 16 1/2 hours after fertilization. E. Egg, 0.9 mm diameter, tail-free stage embryo, 40 hours after fertilization. F. Egg, 0.9 mm diameter, advanced embryo, 90 hours after fertilization. (*A-G, Welsh, W. W., and C. M. Breder, Jr., 1922: figs.* 87, 81.)

cated in posterior part of iris and on tip of snout; tail tip overlaps head; very active.

112 hours—hatching begins, increased pigmentation; pigmentation terminated posteriorly abruptly about half way between vent and tip of tail, at this point a brilliant opaque chrome yellow spot present on dorsal surface, some individuals hatching before this spot developed; most emerged tail first.[7]

YOLK-SAC LARVAE

Average 2.41 mm at hatching,[7,19] yolk absorbed by 2.55–2.65 mm.[19]

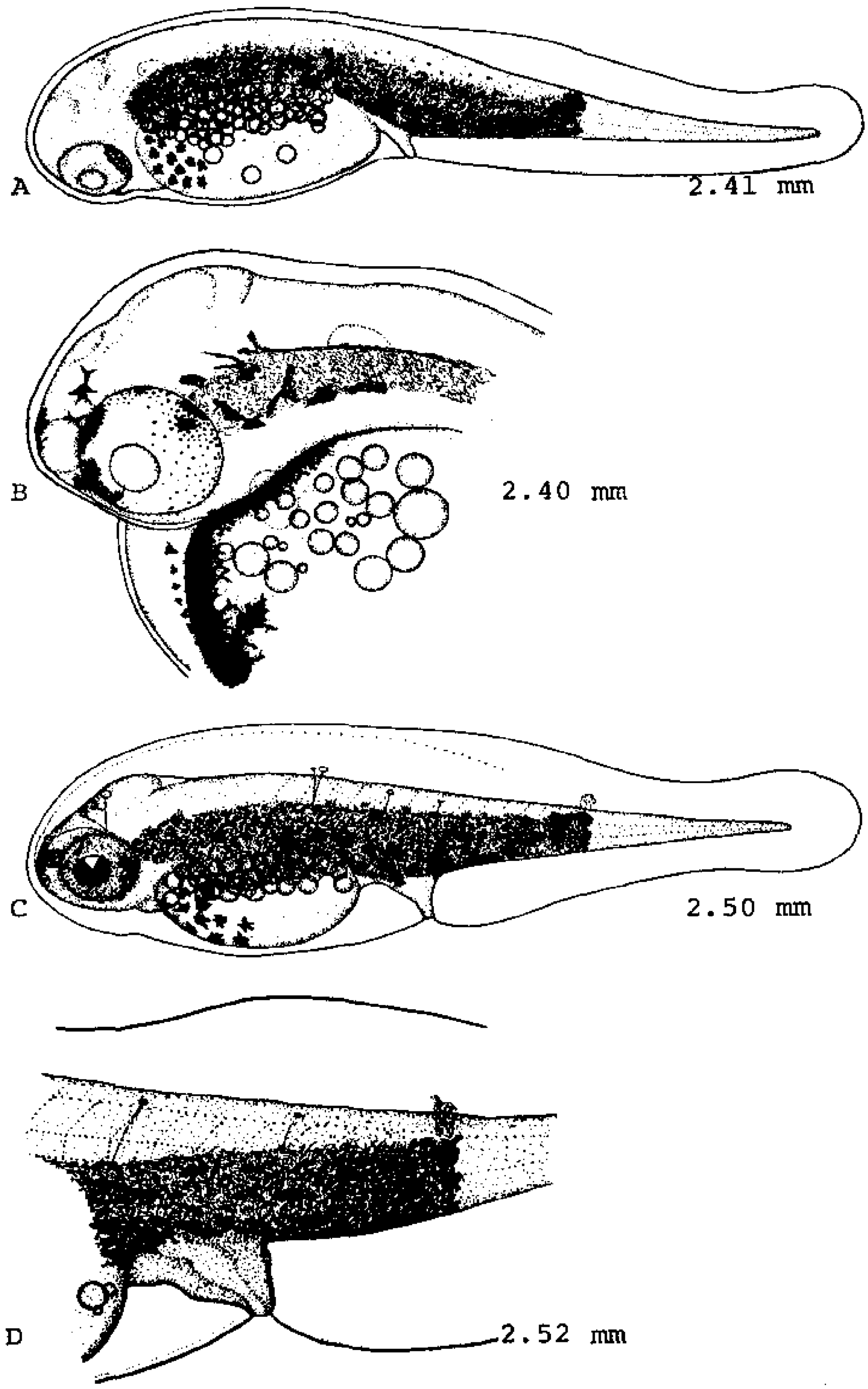

Fig. 152. *Sphoeroides maculatus*, Northern puffer. A. Yolk-sac larva, 2.41 mm, newly hatched. B. Yolk-sac larva, 2.40 mm, close-up of head showing general details and pigment pattern. C. Yolk-sac larva, 2.50 mm, one day after hatching, chrome yellow pigment spot shown in finfold over posterior terminus of pigment. D. Yolk-sac larva, 2.52 mm, details of vent and posterior pigmentation. Note position of dorsoposterior yellow pigment spot over terminus of general pigment. (*A-D, Welsh, W. W., and C. M. Breder, Jr., 1922: figs. 82, 88, 83, 89.*)

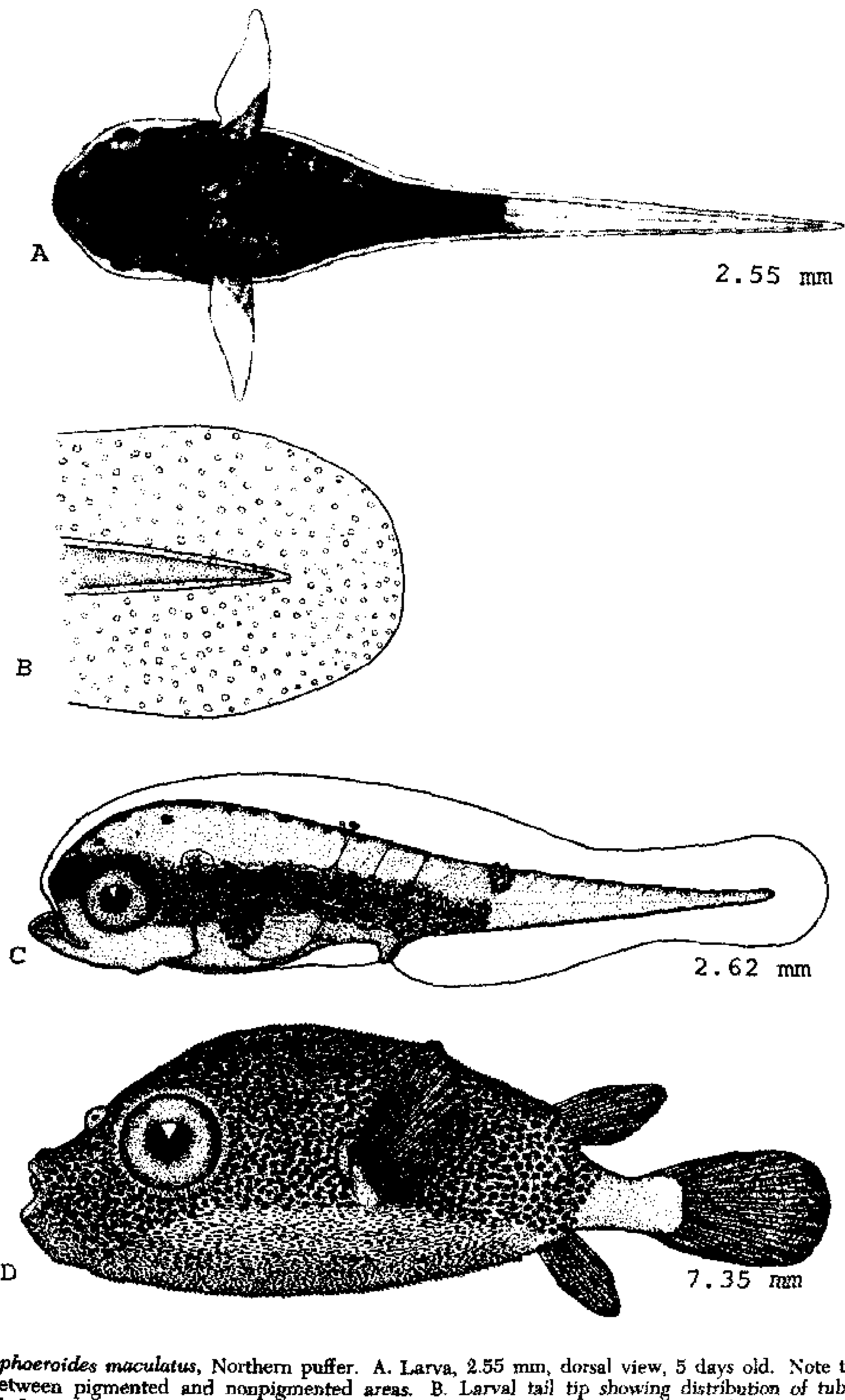

Fig. 153. *Sphoeroides maculatus*, Northern puffer. A. Larva, 2.55 mm, dorsal view, 5 days old. Note the sharp boundary between pigmented and nonpigmented areas. B. Larval tail tip showing distribution of tubercles, 6 days old. C. Larva, 2.62 mm. D. Juvenile, 7.35 mm, pigment still lacking on caudal peduncle. (*A-D, Welsh, W. W., and C. M. Breder, Jr., 1922: figs. 84, 91, 85, 86.*)

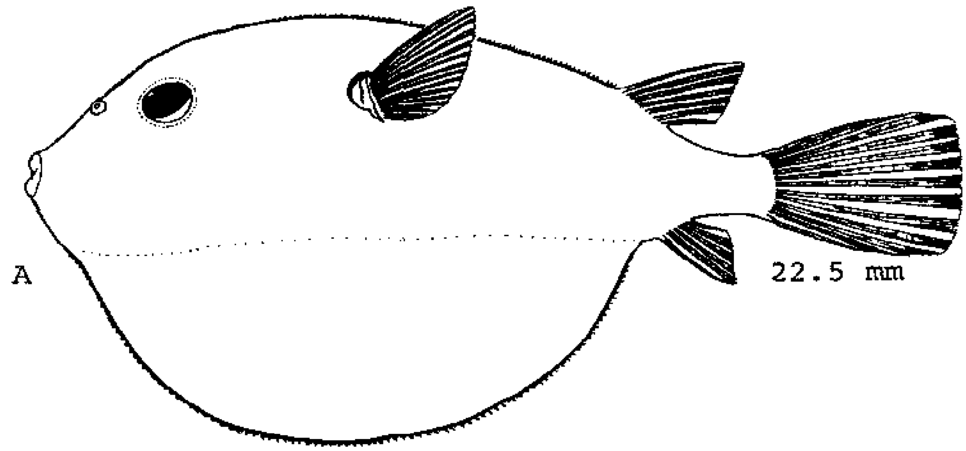

Fig. 154. *Sphoeroides maculatus*, Northern puffer. A. Juvenile, 22.5 mm, showing outline assumed on inflation. (*A, Welsh, W. W., and C. M. Breder, Jr., 1922: 93.*)

Body chunky;[8] head deflected at hatching. Yolk mass small at hatching, visibly reduced at 2 days; oil globules present at hatching; mouth opens 2 days after hatching. Nostrils visible 24 hours after hatching; lateral line organs seemingly beginning at 24 hours after hatching. Pectoral fins present at hatching, more distinct 24 hours after hatching; numerous minute tubercles over entire body; anus opens 2 days after hatching.[7]

Pigmentation: Pupils not yet dark at hatching; heavy pigmentation beneath pectoral fins;[7] brilliant coloration, red, orange, yellow and black chromatophores forming a variegated pattern, tip of tail colorless, a chrome yellow spot marking the posterior abrupt ending of the chromatophores;[7,19] deep purplish black chromatophores covering anterior end of yolk sac and some scattered through the iris which also contains a cluster of heavy black chromatophores in the posterodorsal quadrant.[7] As development proceeds red pigment becomes relatively reduced and orange and yellow become more prominent. About 24 hours after hatching pupil black.[7]

2 days after hatching green markings appear, especially in iris, under reflected light colors brilliant and metallic; chrome yellow caudal spot and a few black spots on head are only dorsal pigmentation.[7]

LARVAE

Yolk may be absorbed by 2.55 mm (5 days) to 2.65 (10 days),[19] fins complete by at least 7.35 mm.[21]

Maxillary well formed and prominent at 5 days; otoliths becoming more complicated in conformation at 6 days; small spine developing on operculum at 5 days after hatching. Pectoral fin becoming less spatulate at 5 days,[7] well developed at 2.65 mm (10 days).[19] Fifth day after hatching numerous tubercles of considerable size on ventral surface, at 6 days tubercles over whole body.[7]

Pigmentation:
- 5 days—melanophores on abdomen dendritic.[7]
- 6 days—body becoming opaque.[7]
- 10 days—iris metallic green.[19]

JUVENILES

7.35 mm [21] to 90 mm.[5]

Skin more distensible than that of adult at 7.34 mm, by 22.5 mm, no more inflatable than adult.[7] Prickles dense in individuals as small as 10 mm.[9]

Pigmentation: All specimens below 40 mm and some up to 100 mm lack pepper spots.[9]

GROWTH

No information.

AGE AND SIZE AT MATURITY

Mature by 70–100 mm SL.[13]

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Sphoeroides pachygaster (Müller and Troschel), Blunthead puffer

ADULTS

D. 8–9 (rarely 7);[1] A. 8[5]–9;[2] C. 11, first upper and 2 lower rays unbranched; P. 14[1]–18.[2]

Body proportions as percent SL or HL: Head 38.1[2]–40.1 SL;[5] snout 18.8 SL[2] or 45.4–52.6 HL;[1] eye 8.12[2]–10.4 SL[5] or 22.2–33.3 HL;[1] predorsal length 71.9 SL.[2]

Body with dorsal profile slightly convex, ventral profile quite convex; head with upper profile convex.[2] Lateral line indistinct and difficult to trace; dorsal and anal fins may have basal cutaneous folds or sheaths.[4] Dorsal fin a little rounded,[2] inserted behind base of last dorsal ray;[1] caudal fin truncate;[1,2] pectoral fin moderately short,[1] base width about equal to eye diameter.[2]

Pigmentation: Color uniform brown or gray on dorsal and lateral surfaces, belly white;[1,2] specimens from western Atlantic and juveniles from eastern Atlantic with dark round or oval spots several millimeters in diameter, these spots more prominent laterally;[1] caudal dark with whitish margin;[1,2] other fins devoid of pigment;[1] iris gray.[4]

Maximum length: To 250 mm.[1]

DISTRIBUTION AND ECOLOGY

Range: New Jersey throughout western Atlantic to Argentina, 37° S and from much of the African Atlantic and Indian Ocean coasts, probably Nigeria to Natal; also known from St. Helena Island in the Atlantic and from the Philippines and Hawaii in the Pacific.[1]

Area distribution: New Jersey[1,3] and Virginia.[1,2]

Habitat and movements: Adults—found in relatively deep water,[1,5] taken from 25–480 m, most deeper than 100 m.[5]

Larvae—no information.

Juveniles—no information.

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

GROWTH

No information.

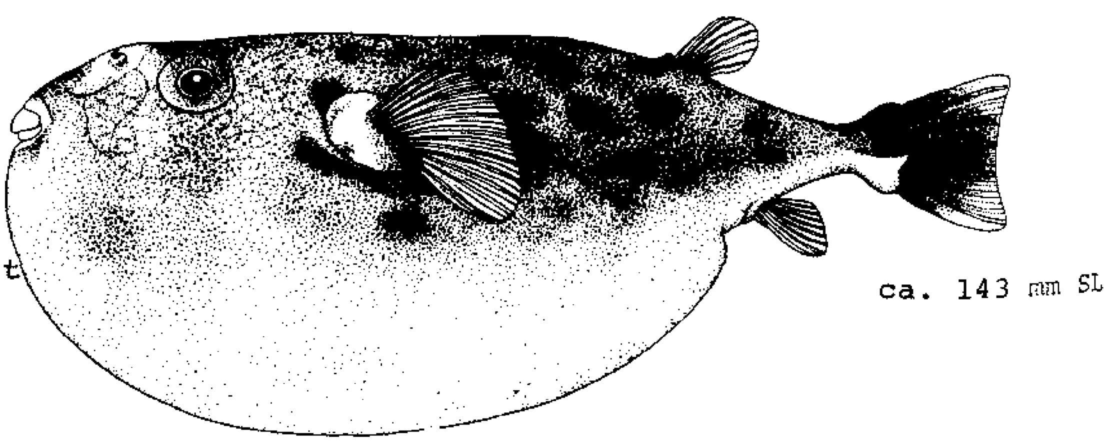

Fig. 155. *Sphoeroides pachygaster*, Blunthead puffer. A. Adult, about 143 mm SL. (*A, Fowler, H. W., 1948: fig. 1.*)

AGE AND SIZE AT MATURITY

No information.

LITERATURE CITED

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5. Cervigon M., F., 1966:842–843.

Sphoeroides spengleri (Bloch), Bandtail puffer

ADULTS

D. 8; A. 7;[1,9,11] C. 11, first upper and 2 lowermost unbranched,[1] 5+6;[11] P. 13–14, not counting rudimentary base present at upper fin sheath which may develop to 25% length of first dorsal ray;[1] vertebrae 17–18, 8+9–10;[11] gill rakers 9–10.[9]

Body proportions as percent SL or HL: Head length 33.3[1]–41.7[3] SL; snout 47.6–62.5 HL; eye .20[1]–.25 HL.[3]

Body oblong[7] or moderately elongate;[9] head compressed, long, snout very long, profile from tip of snout to above eye rising gradually, slightly concave in front of eye.[13] Dorsal and anal fin origins nearly opposite; caudal fin truncate or very slightly rounded, short; pectoral fins short.[1]

Pigmentation: Background color dark green, yellowish brown,[9] brown and gray;[1] pigment restricted to dorsolateral surfaces, white ventrally;[1,19] dorsum blotched, spotted or mottled; interorbit marked by a dark bar of variable intensity, often with anterior and posterior extensions resulting in a cross-shaped marking;[1] lateral pigment bounded ventrally by a row of 11–14 round black spots on head and body;[1,9] just above this row is a region of light pigment, sometimes appearing as a light streak; mottled dorsal pattern begins just above this light colored region; may have 2 distinct dark spots present in the area anterolateral to the dorsal fin;[1] caudal fin with a dark base and distal margin separated by a lighter band;[1,9] iris orange; pale portion of caudal fin orangish;[1] color may lighten or darken in response to background.[12]

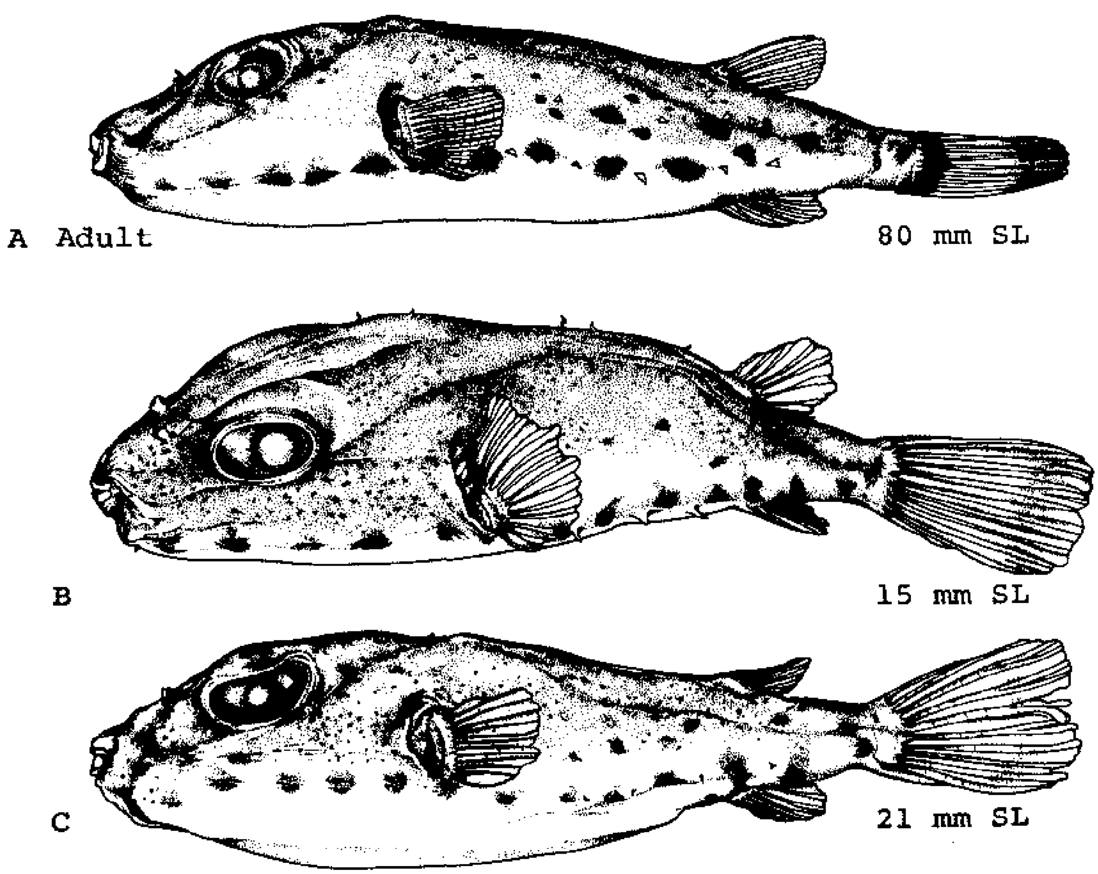

Fig. 156. *Sphoeroides spengleri*, Bandtail puffer. A. Adult, 80 mm SL. B. Juvenile, 15 mm SL. C. Juvenile, 21 mm SL. (*A-C, original drawings by Elizabeth Ray Peters.*)

Maximum length: Reported to 610 mm,[5] this report probably in error, maximum probably about 200 mm SL (RLS).

DISTRIBUTION AND ECOLOGY

Range: Massachusetts to Sao Paulo, Brazil, but common only in the Caribbean, peninsular Florida, the Bahamas and Bermuda.[1] Reports from the Madeira and Canary Islands[8] based on *S. marmoratus* (RLS).

Area distribution: Included on the basis of Shipp's distribution map showing continuous distribution between Massachusetts and Florida.[1]

Habitat and movements: Adults—most often in clear, shallow, tropical waters,[1] over sand,[2,7,8] turtlegrass[1,5] or other seagrasses,[9] or algae,[7] around small patch reefs or in tidal creeks;[5] 14–37.9 ppt[4,6] salinity; 17[1,6]–33.6 C;[6] usually in quite shallow water,[5] down to 55–73 m;[1] most abundant inshore.[4]

Larvae—no information.

Juveniles—grass flats with bare sandy patches;[12] 9.7–38.8 ppt salinity; 18.5–28.0 C.[10]

SPAWNING

No information.

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Reported down to 13 or 14 mm.[10]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

LITERATURE CITED

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5. Böhlke, J. E., and C. C. G. Chaplin, 1968:689.
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9. Randall, J. E., 1968:278–279.
10. Christensen, R. F., 1965:235–237.
11. Miller, G. L., and S. C. Jorgenson, 1973:311.
12. Longley, W. H., and S. F. Hildebrand, 1941:299–300.
13. Evermann, B. W., and M. C. Marsh, 1900:267–268.

Sphoeroides testudineus (Linnaeus), Checkered puffer

ADULTS

D. 8; A. 7; C. 11, first upper and 2 lowermost rays unbranched,[3] 5+6;[10] P. (13) 14–15 (16);[3] vertebrae 18, 8+10.[10]

Body proportions as percent SL or HL: Head length 33.3[3]–37.8[1] SL; snout 43.5–52.6 HL; eye 16.7–25.0[3] HL, 5.8–8.0 SL.[1]

Body robust; head broad with moderately long snout. Scales reduced to prickles. Lateral line evident.[2] Dorsal fin origin directly opposite anus, slightly anterior to anal fin origin; caudal fin slightly rounded, long; pectoral fins moderately long.[3]

Pigmentation: Restricted to dorsal and lateral surfaces; background color gray,[3] brown[3,8] or greenish;[8] shading to whitish on the belly; dorsally a complex pattern of numerous, arching, coarse light streaks or lines, some of which when viewed from above, suggest a pattern of interconnected concentric circles, though many circles are very imperfect;[3,8] numerous dark brown or black spots evident laterally; distal half of caudal fin usually dark brown to black, proximal half light except for a narrow diffuse basal bar; all other fins uniformly straw-colored;[3] iris orange.[8]

Maximum length: To 388 mm TL.[1]

DISTRIBUTION AND ECOLOGY

Range: New England to southeastern Brazil; Bahamas; the West Indies; Central American coast;[8] absent from Gulf of Mexico except for Campeche Bay.[3]

Area distribution: Atlantic coast of Maryland;[4] lower Chesapeake Bay.[2,4]

Habitat and movements: Adults—bays, estuaries[3] and tidal creeks;[3,8] commonly ascending rivers,[5,6] muddy or sandy areas near shore, especially near mangroves,[1] over turtlegrass;[8] 0.36[7]–38.8 ppt salinity;[9] 15.0[7]–36 C;[9] to 44 m[8] but usually in less than 3 m.[3]

Larvae—upper reaches of estuaries.[9]

Juveniles—upper reaches of estuaries; winter in lower salinity waters;[9] from less than 1 ppt (RLS) to 39.8 ppt salinity; 18.9–30.7 C.[7]

SPAWNING

Location: Probably in shallow water with eggs deposited in loose sand.[9]

Season: Based on presence of juveniles less than 20 mm, season probably continuous.[3]

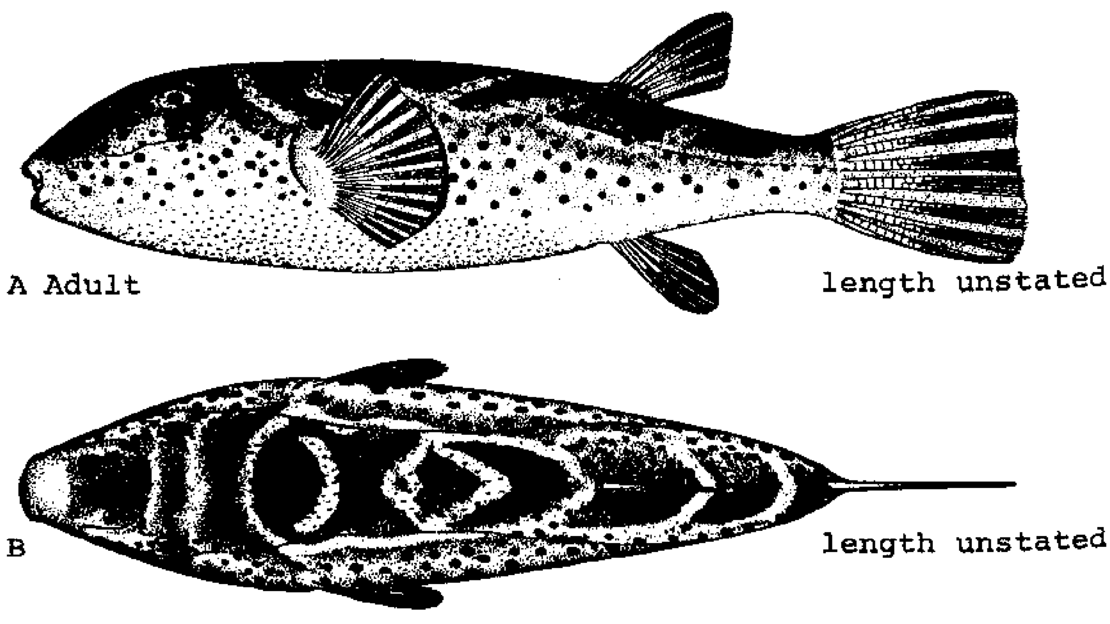

Fig. 157. *Sphoeroides testudineus*, Checkered puffer. A. Adult, length unstated. B. Adult, dorsal view, length unstated. (*Jordan, D. S., and B. W. Evermann, 1896–1900: figs. 646, 646a.*)

EGGS

No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Reported as small as 8–9 mm.

Have adult color pattern by 8–9 mm.[9]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

LITERATURE CITED

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5. Evermann, B. W., and M. C. Marsh, 1900:269.
6. Meek, S. E., and S. F. Hildebrand, 1928:817–819.
7. Gunter, G., and G. E. Hall, 1963:284–285.
8. Böhlke, J. E., and C. C. G. Chaplin, 1968:688.
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Chilomycterus schoepfi
Diodon hystrix

porcupinefishes
Diodontidae

FAMILY DIODONTIDAE

This group of curious looking fishes is primarily tropical in distribution with only two species occurring in this region as strays. Most species are shallow water forms and all described eggs are demersal. They bear a strong resemblance to their near relatives, the puffers, from which they may be easily differentiated by their strong two or three rooted spines.

Chilomycterus schoepfi (Walbaum), Striped burrfish

ADULTS

D. 10–12;[3,13,23] A. 9[23]–12;[3,13] C. 9, 4+5; vertebrae 18–20[23] or 22.[24]

Body proportions as percent TL or HL: Head length 36.4[1,4]–47.6 TL; eye 22.2–26.3 HL.[4]

Body oval, broad and slightly depressed; caudal peduncle small;[3] head short, broad with a short broad snout;[4] mouth terminal, small,[3,4] gape to in front of eye. No lateral line apparent.[3] No true teeth, a continuous plate with a cutting edge, no median suture.[3,13] Body covered with stout, mostly 3-rooted spines, fixed in an erect position.[15] Dorsal fin rounded, inserted far back on body, just before the caudal peduncle; caudal fin long, narrow, rounded; anal fin under dorsal fin; pectoral fin broad, truncate with rounded corners; no pelvic fins.[3,17]

Pigmentation: Background color green to olive or brown, belly pale; back and sides irregularly striped with brown to black lines running posteroventrally,[3,13] considerable variation in number of lines;[15] dark blotch below or on base of dorsal fin,[3,13,15] may be reduced to two isolated spots, one on either side at middle of fin base;[15] blotches behind pectoral fins and above pectoral base;[3,13] blotch *present or absent below eye; blotch about the anal fin* base present or absent;[15] iris brassy yellow, darker toward outer margin; capable of rapidly lightening and darkening general coloration in response to background.[2]

Maximum length: Reported to reach 254 mm.[3,4,13,15]

DISTRIBUTION AND ECOLOGY

Range: New England and the Bahamas to southeastern Brazil, including the Gulf of Mexico;[15] along Atlantic coast of U.S. most numerous from the Carolinas southward, straying to Maine[3,13] and Nova Scotia.[13]

Area distribution: New Jersey;[1,16] Delaware Bay;[18] Atlantic coasts of Maryland[17,20,22] and Virginia;[22] and north in Chesapeake Bay to Patuxent River.[7]

Habitat and movements: Adults—most often on grass beds;[6] move out of shoal waters at the advent of cold weather;[9] 6.9–47 ppt salinity; reported from 12.4–38.0 C,[10] unable to survive 5.8 C, in Texas killed when water temperatures dropped to 4.5 C;[25] reported to 91 m, usually in less than 18 m.[6]

Larvae—no information.

Juveniles—shallow, sandy areas often associated with grass beds;[7] 15.0[11]–37.6 ppt salinity;[19] 10.0[11]–36+ C;[19] usually found along shore.[4]

SPAWNING

Location: Believed to be offshore.[21]

Season: Reported as July[12] or probably early spring;[11] individuals with nearly ripe gonads have been taken in October.[4]

EGGS

Unfertilized eggs demersal, nonadhesive and transparent with an average diameter of 1.8 mm.[5,12]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

Yellow-green at 38 mm.[7]

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information except that a 190 mm female was reported with ripe eggs.[12]

LITERATURE CITED

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4. Hildebrand, S. F., and W. C. Schroeder, 1928:350–351.
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6. Franks, J. S., *et al.*, 1972:127.
7. Schwartz, F. J., 1960:212.
8. Schwartz, F. J., 1963a:622–623.
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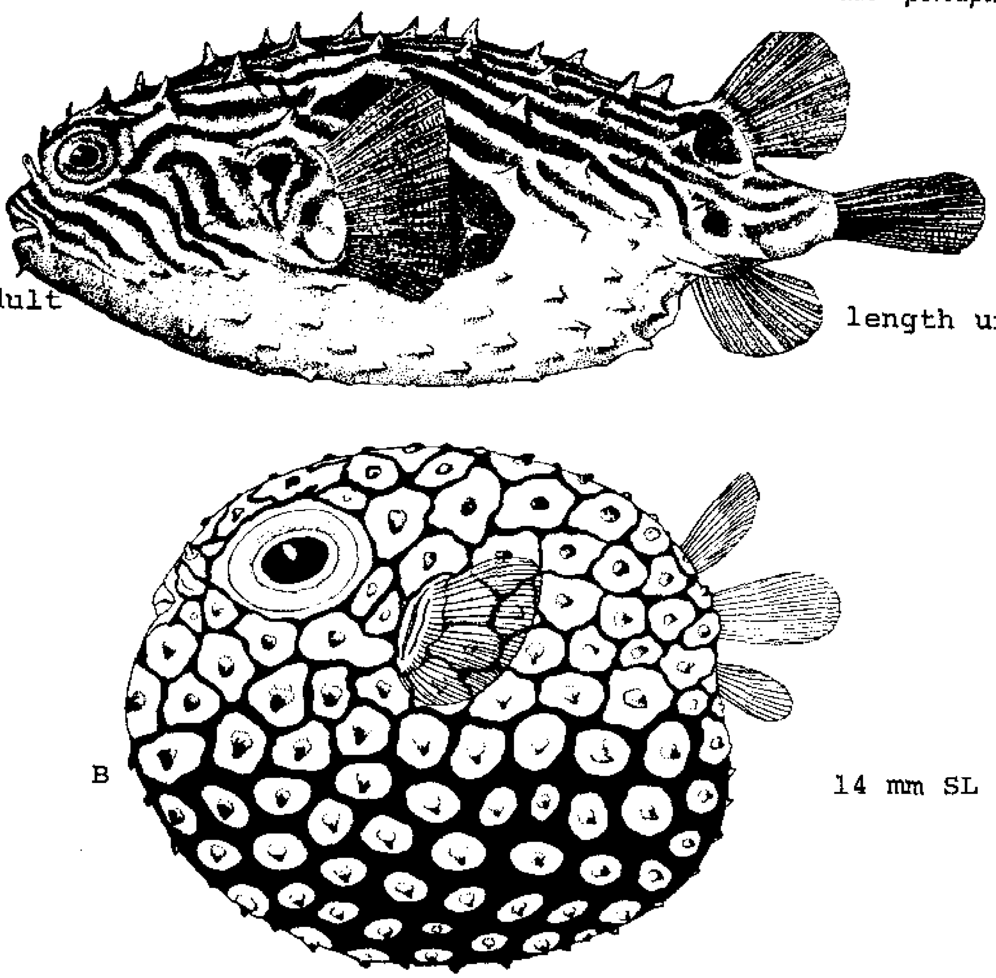
11. Christmas, J. Y., and K. S. Waller, 1973:391–392.

A Adult

length unstated



B

14 mm SL

Fig. 158. ***Chilomycterus schoepfi***, Striped burrfish. A. Adult, length unstated. B. Juvenile, 14 mm SL. (*A, Smith, H. M., 1907: fig. 159. B, Fowler, H. W., 1945: fig. 207.*)

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14. Miller, J. M., 1965:103.
15. Böhlke, J. E., and C. C. G. Chaplin, 1968:693, 698.
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20. Truitt, R. V., B. A. Bean, and H. W. Fowler, 1929: 103.
21. Springer, V. G., and K. D. Woodburn, 1960:89–90.
22. Schwartz, F. J., 1961a:402.
23. Miller, G. L., and S. C. Jorgenson, 1973:305.
24. Moffett, A. W., 1957:18.
25. *Moore, R. H., 1976a:463.*

Diodon hystrix Linnaeus, Porcupinefish

ADULTS

D. 12[6,9,10]–16[2] world-wide, western Atlantic 13[3,4]–16;[2] A. 12[3,4,6,10]–16[2,13] world-wide and western Atlantic; C. 8[11] or 9, 4+5;[13] P. 22–23[9] or 25;[2,11] vertebrae 20; gill rakers 6, all rudiments.[9]

Body proportions as percent TL, HL or SL: Depth 33.3–40.8 TL;[4] head length 51.1 SL[1] or 41.7–45.4 TL;[4] eye 26.0[3]–35.0 HL[4] or 9.8 SL.[1]

Body robust,[3,4] broader than deep; head depressed, noticeably broader than deep; mouth broad.[3] Teeth represented by a single plate with no median suture.[16] Spines of skin long, mostly 2-rooted, folding back when fish not inflated.[7] Dorsal fin inserted a little in advance of anal fin; caudal fin rounded;[17] upper lobe of pectoral fin little longer than lower.[14]

Pigmentation: Ground color of back olivaceous,[1,4] greenish[7] or greenish yellow;[1] underside whitish[1,4,7] or dusky,[4] a gray or dusky ring on the venter margining the white,[1,7] a band coming up from this ring to the eye with another on cheek;[7] back and sides marked by numerous small, roundish spots, these also extending onto the fins; may have blotches;[4] upper surface of head dusky; fins dusky greenish; pales considerably when excited.[7]

Maximum length: Reported to reach over 900 mm.[3,7,9,10]

DISTRIBUTION AND ECOLOGY

Range: Circumtropical,[12] in western Atlantic common *from Santos, Brazil*[1] *to Florida,*[5] *drifting in the Gulf* Stream rarely to Massachusetts.[4,5]

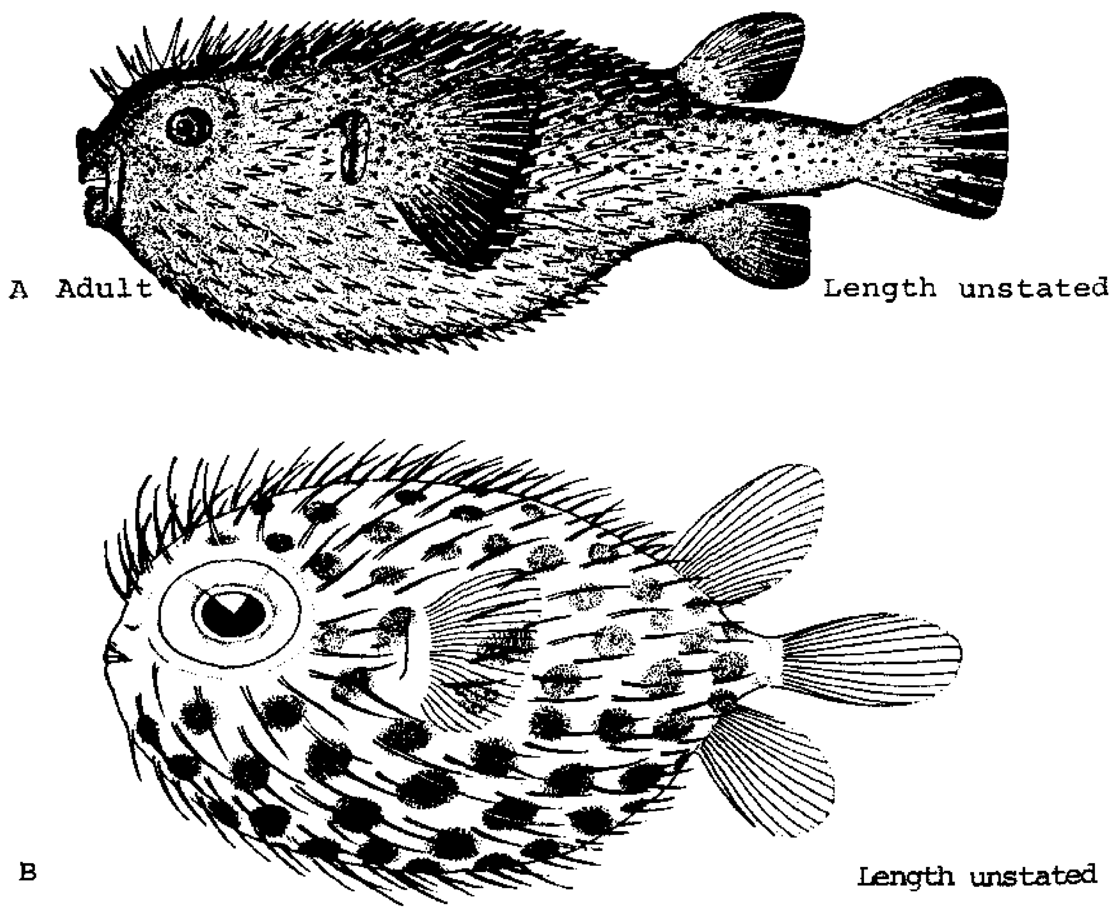

Fig. 159. *Diodon hystrix*, Porcupinefish. A. Adult, length unstated. B. Juvenile, length unstated, but calculated as ca. 15 mm SL. (*A, Smith, H. M., 1907: fig. 158. B, Fowler, H. W., 1928: fig. 79.*)

Area distribution: Lower Chesapeake Bay,[3,11] Atlantic coast of Maryland[11] and New Jersey.[8]

Habitat and movements: Adults—shallow inshore areas,[1,9] also oceanic, pelagic (RAF), coral reefs,[2,5] turtlegrass beds;[7] sometimes in only a few centimeters near shore.[1]

Larvae—no information.

Juveniles—pelagic,[7] found around eelgrass or drifting in floating *Sargassum*.[5]

SPAWNING

In the Caribbean ripe females were found in February and March.[15]

EGGS

No information.

YOLK-SAC LARVAE

No information.

LARVAE

No information.

JUVENILES

No information.

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

LITERATURE CITED

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10. Smith, J. L. B., 1965:415.
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14. Jordan, D. S., and B. W. Evermann, 1896–1900:1745.
15. Munro, J. L., *et al.*, 1973:81.
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Masturus lanceolatus
Mola mola

molas
Molidae

FAMILY MOLIDAE

The ocean sunfishes have a vast literature; most observations on them seem to find their way into print. Gigantic size and weight of some individuals, very unique anatomy that is challenging to describe in conventional ichthyological terms, complex life history including more than one metamorphosis during development, considerable individual variability in shape and coloration, and an inaccessible oceanic habitat from which they unpredictably appear in widely separated places are all factors in their scientific notoriety. Most systematic comparisons rest on published data; the bulk and shape of adults make them very difficult to preserve adequately, and even good photographs are rare.

Schmidt (1921b) and Fraser-Brunner (1951) have attempted to sort out the confusion in published names, which, with spelling permutations, number about 80. Schmidt reduced these to three species in two genera, *Ranzania* and *Mola*. Fraser-Brunner elevated Schmidt's genera to subfamilies and recognized *Ranzania laevis* (Pennant), *Mola mola* (Linnaeus), *Mola ramseyi* (Giglioli), *Masturus lanceolatus* (Lienard) and *Masturus oxyuropterus* (Bleeker), with the qualification that the last two are probably sexes of the same species. He suggested that the *oxyuropterus* form might represent females, but Glover (1966) has subsequently reported a female specimen that seems to fit *M. lanceolatus* as characterized by Fraser-Brunner. Most recent authors have ignored the name *oxyuropterus*, e.g., Parin (1968), but have otherwise followed Fraser-Brunner's usage of names. *Mola ramseyi* is apparently restricted to the South Pacific; *Mola alexandrini* (Ranzani) in South Africa (Barnard, 1935, 1948) may be a valid species (JCT); all the others mentioned are cosmopolitan in tropical to temperate seas. *Ranzania laevis* has not been reported inside the geographic limits of the study but occurs in the nearby Gulf Stream; it has been incorporated in the key below as a form that may stray into the coastal fauna, also making the key applicable to the North Atlantic Ocean in general.

Any molid larger than early larvae is immediately recognizable by the lack of a caudal peduncle. Young larvae have a typical tetradontiform shape with a caudal lobe on the finfold (Schmidt, 1921a, 1921b; Sanzo, 1919, 1939; Aboussouan 1969). The caudal area appears to degenerate as larvae advance into a so-called ostracioniform phase (Tortonese, 1956). However, if the 17 myomeres figured by Sanzo (1939) for *Mola mola* correspond to the 17 adult vertebrae in the usual way, only the 0.17 mm or so of protruding urostyle and the caudal finfold actually degenerate or are overgrown, the significant event, or non-event, being failure to produce hypural elements. Sanzo (1939) is the only one to portray or discuss myomeres of larval molids and his figure is unique in that all of the myomeres appear to be postanal myomeres. It is therefore possible that more than 17 are actually present and that some degeneration of the posterior caudal trunk does occur.

The posterior fin of molids, which functions as a rudder (Damant 1925), is supported by rays apparently derived from the posterior parts of the dorsal and anal fins and, in *Masturus* only, a central lobe contains rays that may represent true caudal rays (Ryder, 1886; Gudger, 1937b; Raven, 1939; Fraser-Brunner, 1951; Tyler, 1970). The structure, therefore, cannot legitimately be called a caudal fin. Raven and Tyler have termed it a pseudocaudal fin, while Fraser-Brunner proposed an independent name, the clavus. At least partly to avoid the conceptual difficulty with *Masturus* of caudal rays in pseudocaudal fin, the terms clavus and claval structures (rays, etc.) are used here.

It is intriguing to speculate on the origin of the rays in the claval lobe of *Masturus*; in larvae or young prejuveniles figured by Schmidt (1921a, b, 1939) and McCulloch (1912) some rays apparently destined to occupy the lobe appear to be epaxial in respect to the primitive notochord tip. If so, and if these are true caudal rays, they would not correspond to principal caudal rays of other teleosts. Without hypural elements as reference, answers to the many questions raised must wait on detailed study of the critical size range from 3 to 10 mm TL.

Lack of hypurals also makes the term "standard length" technically unsuitable for molids, since it is defined in terms of the hypural plate. The claval rays are unsegmented (Tyler, 1970) and hinged at the base to create a junction line even sharper and easier to locate than the usual teleostean hypural border. While no substitute measurement for standard length is available in most of the literature on *Mola mola*, total length was judged to be consistent enough for general morphometric comparisons. A trailing claval whiplash, longer than the body length ahead of the clavus, in two juvenile *Masturus* specimens (King 1951) is evidence that the claval lobes of the adults reported have been variously amputated, and that, with this genus, total length is completely useless for comparative proportional measurements. The term preclaval length (PCL) is proposed as a substitute for standard length, defined as length in the vertebral axis (relatively straight and horizontal in this family) from the tip of the upper jaw to the anterior claval border or hinge line (viz., Hart, 1973). Notice, incidentally, that morphometrics based on PCL are not available for *Mola*, and that those based on TL are not directly comparable to those calculated for *Masturus*.

Recognition of a prejuvenile (molocanthiform) stage in molid development seems warranted, since larval spines and very different body proportions from adults are retained well beyond the size at which the definitive fin ray counts are established. The lower limits of the stage are not clearly defined, however, partly because most of the material reported has come from the stomachs of predatory fishes, in which the delicate fins may have been damaged or destroyed. A critical examination of specimens in the size range 3–13 mm TL is needed. Schmidt (1921a, b), Gudger (1937a) and Fitch (1950) indicated that abundant material has been collected.

Steenstrup and Lütken (1898) provided the first extensive monograph on this family (in Danish), and their careful illustrations remain valuable even though many of their systematic conclusions did not stand the test of time. Their system of numbering larval-prejuvenile spines, although somewhat cumbersome, is the only one that has been proposed. It is reproduced here on a redrawing that has been reversed right to left and shows odd numbered paired spines rather than the even numbered spines visible on the animal's right side. The relative lengths of mid-dorsal unpaired spines provide simple identification of small prejuveniles. Schmidt (1921b), incidentally, mentioned that spines of Molidae exhibit transverse as well as longitudinal ridges, in distinction to Ranzaniinae. This statement has been cited by others, but the author was unable to find an illustration of the feature. A network of intersecting ridges was well developed on the spines of a 14 mm TL *Mola mola* (USNM 217452) examined, and is illustrated with that species. Note also that the serrations of the longitudinal ridges point outward from the body, probably rendering the burr-like creature even more difficult for small predators to ingest. Unfortunately, this specimen has been partially digested, by a large predator, and is not suitable for complete illustration.

Spines of the specimen examined were arrayed exactly as in the illustrations of Steenstrup and Lütken. A similar arrangement of spines can be made out in the 5 mm TL specimen photographed by Schmidt (1926). This photograph was delineated by Fraser-Brunner (1951) omitting spines 11, 13, 21 and 23, as well as the small unnumbered spines anterodorsal to the pectoral fin, and also by Tortonese (1956) omitting spines 9, 19, and 23 and placing what appears to be spine 17 in the mid-dorsal line. This attempt at delineation and the interpretations may be similarly criticized; hopefully this specimen or others of the same size can someday be illustrated in a way to end speculation.

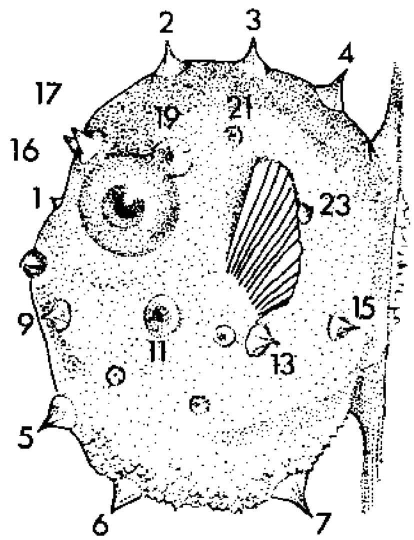

Fig. 160. *Mola mola,* 15 mm TL, illustrating spine numbering system for molid larvae and prejuveniles. Even numbers 8–22 apply to right side of the animal (only no. 16 visible above). (*Steenstrup, J., and C. Lütken, 1898: pl. 4, fig. A., reversed and correspondingly renumbered, redrawing by Joan Ellis.*)

In distinguishing two forms of *Masturus,* Fraser-Brunner (1951) indicated for all sizes a distinct bimodality of ray counts in the median lobe of the clavus; eight (rarely seven or nine) in *lanceolatus* and four (rarely three or five) in *oxyuropterus.* Several authors, including Schmidt (1921b) and Gudger (1937b) have mentioned the difficulty of distinguishing rays that belong to the lobe from adjacent claval rays. Perhaps an apparent slip, in listing pl. 6, fig. D of Schmidt (1921) in the synonymy of *oxyuropterus* but pl. 1, fig. 5 of Steenstrup and Lütken (1898) in the synonymy of *lanceolatus,* reveals more uncertainty in Fraser-Brunner's distinction than even he admitted, since Schmidt states that they are photograph and drawing, respectively, of the same specimen. Gudger (1935b and 1939) listed lobe counts of six rays for two juveniles, five for one and four for only one, King (1951) added two more juveniles with lobe counts of six rays, and Tyler's (1970) careful illustration shows five median rays not associated with radial elements. Uncertainties in prejuvenile counts owing to obvious fin damage and in adult counts because of thickness of the obscuring integument supplement the contradiction posed by six of the seven available juvenile counts and all but eliminate this characteristic's relevance for separating forms. Other differences described by Fraser-Brunner apply principally to adults and do appear, as he suggests, to reveal sexual dimorphism parallel to that of *Mola mola.*

A difference unrelated to those discussed by Fraser-Brunner was noticed in compiling proportions of prejuveniles that have been illustrated. The absolute length of spines in larvae from the Atlantic Ocean seems considerably greater than that of Pacific examples, which are unfortunately only represented by drawings. Since the length does not appear to change after about 5 mm TL, it should be measured in future specimens described for at least some of the longer spines.

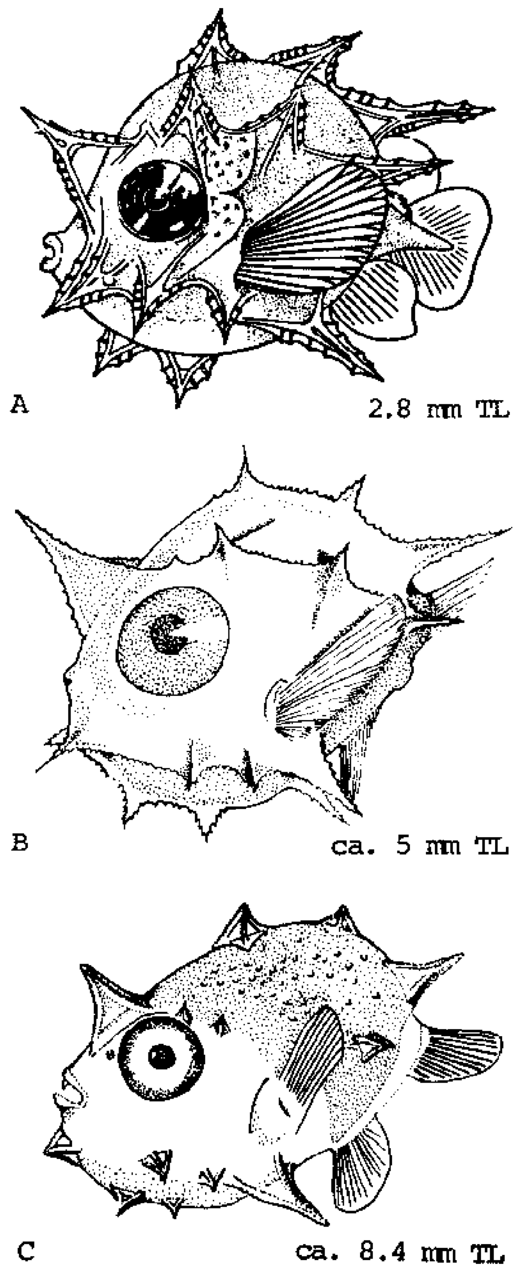

Fig. 161. Early stages of *Ranzania laevis*. A. Larva, 2.8 mm TL. B. Putative prejuvenile ca. 5 mm TL. C. Putative prejuvenile ca. 8.4 mm TL. (*A, Tortonese, E., 1956: fig. 825, after L. Sanzo, 1919. B, Steenstrup, J., and C. Lütken, 1898: pl. 4, fig. H, redrawn by Joan Ellis. C, Scotton, L. N., and D. P. de Sylva, 1972: 201, redrawn by Joan Ellis.*)

Key to spinose larvae and prejuvenile Molidae of the Atlantic Ocean.

1a. Spines with transverse ribs around the base in addition to longitudinal ribs; spines 3, 21 (or 20), 13 (or 12) and 7 aligned in a shallow arc or straight line passing through pectoral origin (**Molidae**) 2

1b. Only longitudinal ribs on spines; spine number 7 (third midventral spine) well ahead of pectoral fin origin and the level of spines 3, 21 and 13; spine 5 (first mid-ventral spine) between spines 8 and 9 (anteroventral eye spines); spines 1 and 4 (first and last mid-dorsal spines) much longer than spines 2 and 3 (the middorsal spines between them) (**Ranzaniinae**) .... *Ranzania laevis*

2a. Spines 1 and 3 much longer than spines 2 and 4; spine 5 longer than spines 6 and 7; profile of chin angled at base of spine 5 (first mid-ventral spine) when young; spine 17 (or 16) much shorter than spine 19 (or 18) .... *Masturus lanceolatus*

2b. Spine 1 (first mid-dorsal spine) minute, spines 2, 3 and 4 similar to each other in length; chin profile rounded; spine 17 (or 16, anterodorsal eye spines) almost as long as spine 19 (or 18, posterodorsal eye spines) .... *Mola mola*

Masturus lanceolatus (Lienard), Sharptail ocean sunfish

ADULTS

P. 7 [39]–10 [11,36] (17 [38] an error [11]); V. absent; [1] clavus [5] (pseudocaudal [1,23]) with 4–8 [1,5,15] in median lobe (possibly true caudal rays [5,12]), 6–7 above lobe [1,15,23] (derived from dorsal fin [5,12,23]), and 7–11 below lobe [1,15,23] (derived from anal fin [5,12,23]); total D. + A. + C. 55 [5]–64 [11] (55–57 in *oxyuropterus* form, 60 + in *lanceolatus* form [5]); D. (excluding clavus) 18 [3,30]–20; [36] A. (excluding clavus) 16 [40]–18 [3,30,36] (19 [3] quoted incorrectly,[30] 21 [38] doubtful, GED); vertebrae 16 (8 + 8); [1] gills 4; branchiostegals 6.[5]

Range of proportions as percent of PCL (preclaval length, defined in family introduction) unless otherwise stated: Distal tip of dorsal fin to distal tip of anal fin 140 [34]–154 [13] *(ca. 110% of TL[34]); greatest depth of body* (dorsal fin origin to anal fin origin where known) ca. 54.6 [22] (PCL estimated, GED) or 66–71; [13,33,34,39] pectoral fin length 12.1 [22]–14.2; [34] dorsal fin height 36.9 [39]–49.5; [13] anal fin height 42.7 [39]–45.9; [13] pectoral fin base ca. 6.3; dorsal fin base 23 [39]–ca. 25; [22] anal fin base ca. 23; [22,39] head 35.3; [34] snout 80% of head; [36] eye 4.3 [39]–5.8 [34] (axis unstated), on longitudinal axis 4.1–4.8, on vertical axis 3.7–4.2; [13] interorbital width 16.5 [39]–18.4; [34] greatest body width 20.2 [13]–29.0; [39] width of mouth 6.3 [34]–9.7; [39] diameter of gill aperture 7.3 vertical,[13,34] 5.0 longitudinal; [13] length of gills 36.7; [13] horizontal length of clavus 27.3 [39]–28.4 (22.1% of TL [34]).

Body compressed, elongate ovoid,[36] oval lanceolate in cross section.[37] Head wider than body,[33] without ridges above or below eyes,[37] its dorsal profile more evenly arched than that of *Mola;* [30] snout rounded; chin not prominent [31] (*oxyuropterus* form [5]) or prominent anteriorly [37] (*lanceolatus* form [5]); interorbital region broadly convex; [36] eye oblong,[13] closer to tip of snout than to *base of pectoral fin,*[30] *with nictitating membrane;* [13] nostrils inconspicuous; [36] mouth small, terminal,[31,36,37] outline of gape almost circular when mouth open,[13] tongue broad [36] and hard,[33] not free; [36] gill rakers concealed in thick skin; [37] gill openings reduced to mere spiracles,[1] directed backward,[34] semicircular,[33] extending somewhat under pectoral fin bases, not separated from them by a strip of skin as in *Mola.*[37] Pectoral fins short and rounded, *somewhat smaller in proportion than those of Mola* (GED); no pelvic girdle or pelvic fins; [1] dorsal and anal fins similar and opposed, used in locomotion, anal fin origin slightly behind dorsal fin origin, both united with clavus [5] or pseudocaudal fin [1,23] by broad membranes; [36] clavus used in steering, capable of bending almost to 90° angle with body axis,[13] dorsal and ventral portions meeting in a median, fleshy flap [18,36] that contains rays unsupported by radial elements and may represent a true caudal remnant [5,12] (evidence for this still equivocal [23]), point of clavus evidently variously shortened or mutilated in adults; [9] claval rays not branched distally in adults; [5,37] all median fin rays obscured by thick integument.[35] Collagenous hide of body essentially similar to that of *Mola*, underlying flesh said to resemble that of some deep sea fishes; [34] integumentary scutes finer and less evident to the touch than those of *Mola,*[26] each scute with a narrow oblong base and several conical multipointed cusps,[33] points directed posteriorly and sandpapery to the touch if stroked toward the head; skin not covered with thick mucus; [18,26] skeleton mostly cartilagenous; [1] one less vertebra than *Mola,* the last bearing a haemal spine and a very reduced neural spine, apparently corresponding to the penultimate vertebra of *Mola;* [23] ovary single.[40]

Pigmentation: Black [37] or blue-black [34,39] dorsally, fading to brown in preservation,[36] dark color extending on snout and dorsal fin,[34] sides and ventral surfaces silvery [33,34,37] with scattered round, poorly defined dark spots on lower sides; [30,33,37] anal fin black at tip shading to silvery at base,[34] bases of anal fin and lower clavus gray with bluish-white spots,[33,34] spots fading to silver after death [34,39] and to gray against a dusky background in preservation; [36] metallic reflections on sides and blue of claval spots intense in life; [33] pectoral fins lighter than back,[39] dusky, membrane paler than rays; iris light mottled brown in life,[13] slaty with a well defined buff band and a buff spot on lower portion in alcohol; [36] lips and interior of mouth in life dark rose with a trace of purple.[13]

Maximum size: Largest reported specimens from Atlantic, 2591 mm TL (Cuba) [32] and 2540 mm TL (Miami, Florida), the latter 1880 mm PCL,[30] an older Miami specimen claimed to have exceeded 3000 mm TL; [5,35] *largest elsewhere 2296 mm* TL (*the type* Indian Ocean [38]); no Pacific records larger than 1220 mm TL.[31]

DISTRIBUTION AND ECOLOGY

Range: Universally distributed in warmer parts of all oceans,[9] the range similar to that of the sargassum fish, *Histrio histrio* (GED); penetrating into temperate lati-*tudes but encountered more rarely than Mola mola;* [9] not reported in Mediterranean Sea [21] or eastern Pacific. Northernmost record a sighting on St. Pierre Bank at 45° 02′ N, 55° 13′ W east of Nova Scotia,[7] eastern Atlantic limits presently Azores,[3,14,22] Canary Islands [3,14] and Madeira Islands.[3] Reaching South Africa,[3,37] Brazil,[41] the western Caribbean,[3] the Gulf of Mexico [6,16] to Mississippi,[6] the south Pacific,[3,4,20,31,34] Australia,[46] Indian Ocean [3,38] and Japan.[10,27,30] Young stages most common from south of Japan [17] to Hawaii [8,29] in the northwestern

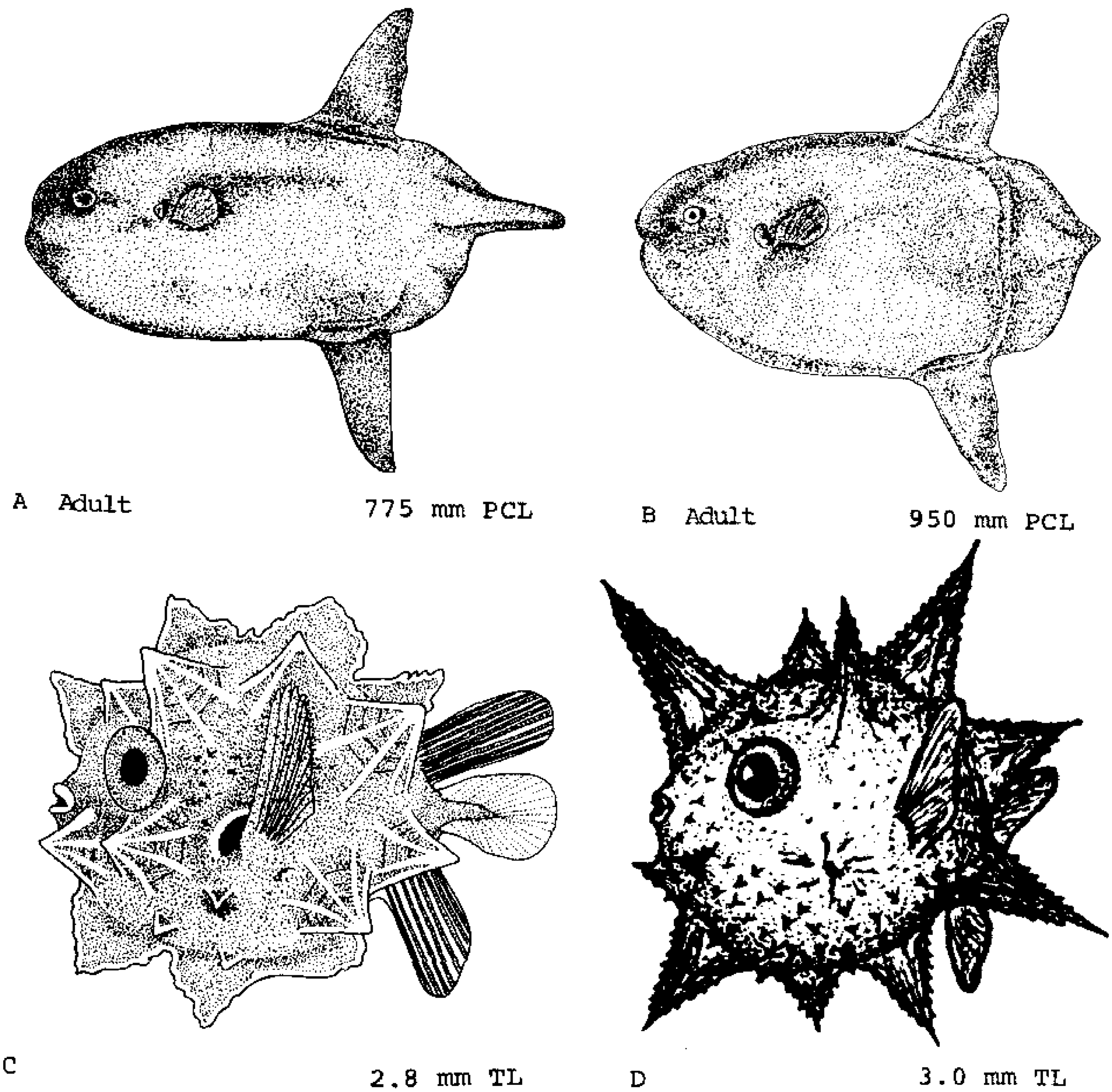

Fig. 162. ***Masturus lanceolatus***, Sharptail ocean sunfish. A. Adult (or subadult), *lanceolatus* form, 775 mm PCL (953 mm TL). B. Adult, *oxyuropterus* form, 950 mm PCL (1220 mm TL). C. Larva, 2.8 mm TL. D. Larva (or prejuvenile), 3.0 mm TL. (*A, Gudger, E. W., 1935a: fig. 1, delineated by Tamiko Karr. B, Smedley, N., 1932: pl. 1, delineated by Tamiko Karr. C, Schmidt, J., 1921b: fig. 14c, delineated by Tamiko Karr. D, Sokolovskaya, T. S., and A. S. Sokolovskiy, 1975: fig. 2d.*)

Pacific, and in the Sargasso Sea of the northwestern Atlantic,[3,11,19,25] adult records concentrated in Cuba,[32,33] Florida[2,30] and South Africa.[8,37]

Area distribution: Occasionally off outer beaches in late summer throughout region (FJS); a Gulf Stream species apt to occur inshore under the same conditions that bring in *Histrio histrio* (GED).

Habitat and movements: Adults and juveniles—oceanic, considered epipelagic;[9] movements largely unknown (GED); generally entering the Sea of Japan in October with the Tushima warm current.[42] Depth distribution unknown, benthic sponges in stomach of Japanese juveniles 70 mm PCL;[10] a Mississippi specimen trawled at depth of 37 m.[6]

Larvae and prejuveniles—taken in nets at depths somewhat greater than similar stages of *Ranzania*, always dead when retrieved [25] (*Ranzania* found in upper 25 m layer [17]); benthic annelids found in stomach of Japanese prejuvenile 37 mm PCL; [10] majority of young *Masturus* reported from stomachs of larger carnivorous fishes: *Thynnus*,[5,27] *Coryphaena*,[2,8] *Acanthocybium*,[10] etc.

SPAWNING

Location: Central parts of the subtropical circulations,[9,19] Pacific prejuveniles all within 25° of the equator.[3,17,20]

Season: No direct information. A few dates correlated with size: Pacific young 2.9–12.0 mm TL in February, April and August,[17] Atlantic young 22 mm TL in January, 53 mm PCL in October.[3]

Temperature and salinity: No information.

Fecundity: A large quantity of ovarian eggs.[40]

EGGS

Location: Pelagic.[11]

Unfertilized eggs: Immature ovarian eggs yellow,[40] no other information.

Fertilized eggs: Diameter ca. 1.8 mm; larger than the eggs of *Ranzania* from the same area; oil droplets many, ca. 40 (versus ca. 20 in *Ranzania*); [11] no other information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No particular sizes described; newly hatched larvae possessing a primary tail; none of the spines remarkable for special length; [11] no other information.

LARVAE

Specimens described: 2.8 mm TL and possible larva 3.0 mm TL. Length at end of stage probably less than 6 mm, possibly ca. 3 mm TL (GED).

At 2.8 mm TL urostyle and surrounding finfold still present, faint striations radiating dorsal and ventral to urostyle (retouched to resemble rays in Schmidt's figure); ca. 10 well developed pectoral rays; ca. 9 dorsal and 8 anal rays discernible; a series of wedge-shaped or pyramidal spines present; [15] (additional description, GED, based on retouched [15] photograph [11] and two less clear but unretouched prints from same negative [8,15]) all spines to be found on larger specimens recognizable, with both longitudinal and transverse ridges, the longitudinal ridges serrate; eye ca. 17% of body length; several spines longer than eye diameter, and posterodorsal eye spines longer than anterodorsal eye spines (the latter two features distinguishing this stage from *Mola*); anteroventral paired eye spines well dorsad to first mid-ventral spine (distinguishing *Masturus* from *Ranzania*); origin of pectoral fin behind midpoint of body length without caudal, near midpoint of total length.

At 3.0 mm TL (description, GED, based on an illustration [17] in which spines 13 and 15 occlude view of caudal region; fin ray counts not stated) first and third *mid-dorsal spines (1 and 3), first mid-ventral spine (5)*, and paired spines posteroventral to pectoral fin origin (12 and 13, right and left, respectively) almost twice as long as spines 2 and 6 and noticeably longer than spines 4 and 7 (diagnostic of the species at this and *larger stages); spines strongly serrate along edges;* proportions otherwise similar to preceding description.

PREJUVENILES

Specimens described 5.0 mm TL–54 mm PCL. Size at end of stage 55–60 mm PCL, characterized at this size by disappearance of spines and a gradual metamorphosis to adult body proportions, especially in depth from dorsal fin origin to anal fin origin, and in placement of pectoral fins (GED).

At 5–5.5 mm TL (Atlantic specimens) body deeper than long; spines 1, 3, 5, 12 and 13 greatly elongated, longer than body, with longitudinal and transverse ribs on spine bases; anterodorsal eye spines rudimentary; [11,15,25] fin ray counts not stated, estimated as P. ca. 10, D. ca. 8, A. ca. 9 [15] (D. and A. exclusive of clavus, estimated from photographs with median fins in oblique view, GED); caudal fin reduced to a minute knob, possibly with a faint remnant of finfold tissue; pyramidal serrated spines lacking [15] (the latter inconsistent with next figure below; additional description, GED, based on photographs [11,19,25]) pectoral fin origin behind midpoint of PCL, near midpoint of body depth; eye diameter ca. 26% of PCL; three pairs of unnumbered spines on lower sides similar in appearance and position to those of *Mola mola;* anterior and ventral profiles of chin meeting in an acute angle at base of chin spine (no. 5).

At 5.9 mm (PCL?; Pacific specimen, fin ray counts unstated; description, GED, based on figure [17]) shape and proportions of body similar to preceding description, but longest spines much shorter, serrate along edges; a narrow clavus evident with distinct rays; anterodorsal eye spines and unnumbered spine pairs of lower sides not figured.

At ca. 10 mm (TL?; Pacific specimen) body depth ca.

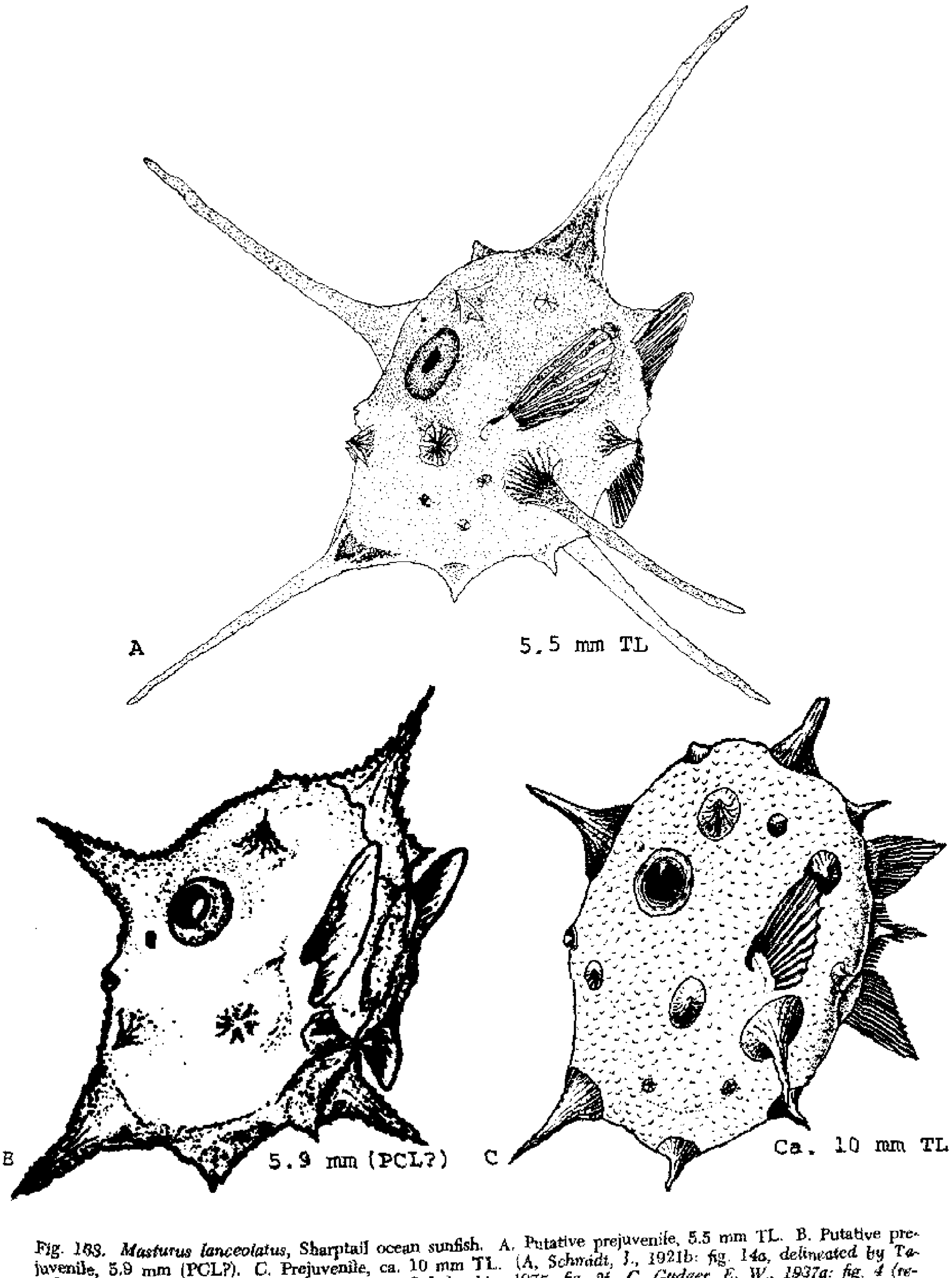

Fig. 183. *Masturus lanceolatus*, Sharptail ocean sunfish. A. Putative prejuvenile, 5.5 mm TL. B. Putative prejuvenile, 5.9 mm (PCL?). C. Prejuvenile, ca. 10 mm TL. (A, *Schmidt, J., 1921b: fig. 14a, delineated by Tamiko Karr. B, Sokolovskaya, T. S., and A. S. Sokolovskiy, 1975: fig. 2f. C, Gudger, E. W., 1937a: fig. 4 (reversed and slightly modified), after McCulloch, A. R., 1912.*)

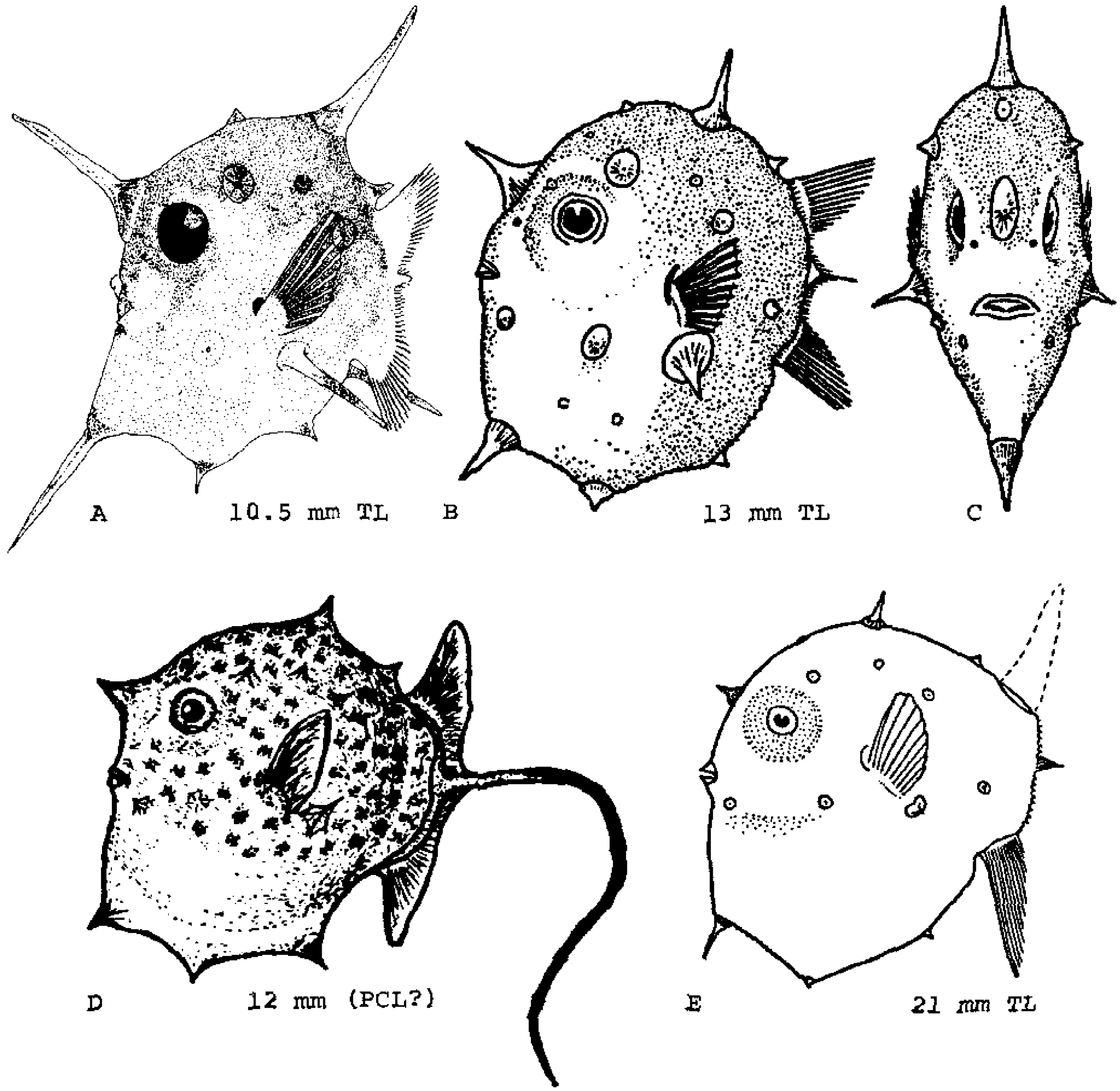

Fig. 184. *Masturus lanceolatus*, Sharptail ocean sunfish. A. Prejuvenile, 10.5 mm TL. B. Prejuvenile, 13 mm TL. C. Anterior view of same specimen. D. Prejuvenile, 12 mm (PCL?). E. Prejuvenile, 21 mm TL. (*A. Schmidt, J., 1932: pl. 167, delineated by Tamiko Karr. B, C, Tortonese, E., 1956: fig. 831 (reversed), after McCulloch, A. R., 1912. D, Sokolovskaya, T. S., and A.S. Sokolovskiy, 1975: fig. 2e. E, Fraser-Brunner, A., 1951, fig. 9.*)

140% of PCL; eye diameter ca. 19% of PCL; P. 11, D. 17, A. 14+ (D. and A. exclusive of clavus); dermal tubercles developed;[20] fleshy bases of dorsal and anal fins more developed than those of 5 mm specimen; a fleshy pointed lobe bearing five rays present near midpoint of claval area;[15] two pairs of unnumbered spines on lower sides evident in original figure[20] (added to Gudger's[15] redrawing reproduced here); angle at base of chin spine obtuse but still distinct (GED).

At 10.5 mm TL (Atlantic specimen) spines relatively shorter than at 5 mm TL,[15] actual length of longest spines (ca. 5.7 mm) remaining virtually unchanged (GED); ray count estimated as P. ca. 10, D. ca. 17, A. ca. 16 (D. and A. excluding clavus), D. + A. + C. complex 50+.[15]

At 13 mm (TL?; Pacific specimen) depth of body ca. 125% of length, in front view broad above and narrow below; eye placed in a shallow depression; width of mouth equal to eye diameter; gill opening oblique, curved, placed behind middle of body length and above middle of body depth; nostril a small simple opening in front of lower part of eye; anus small, just below base of anal fin;

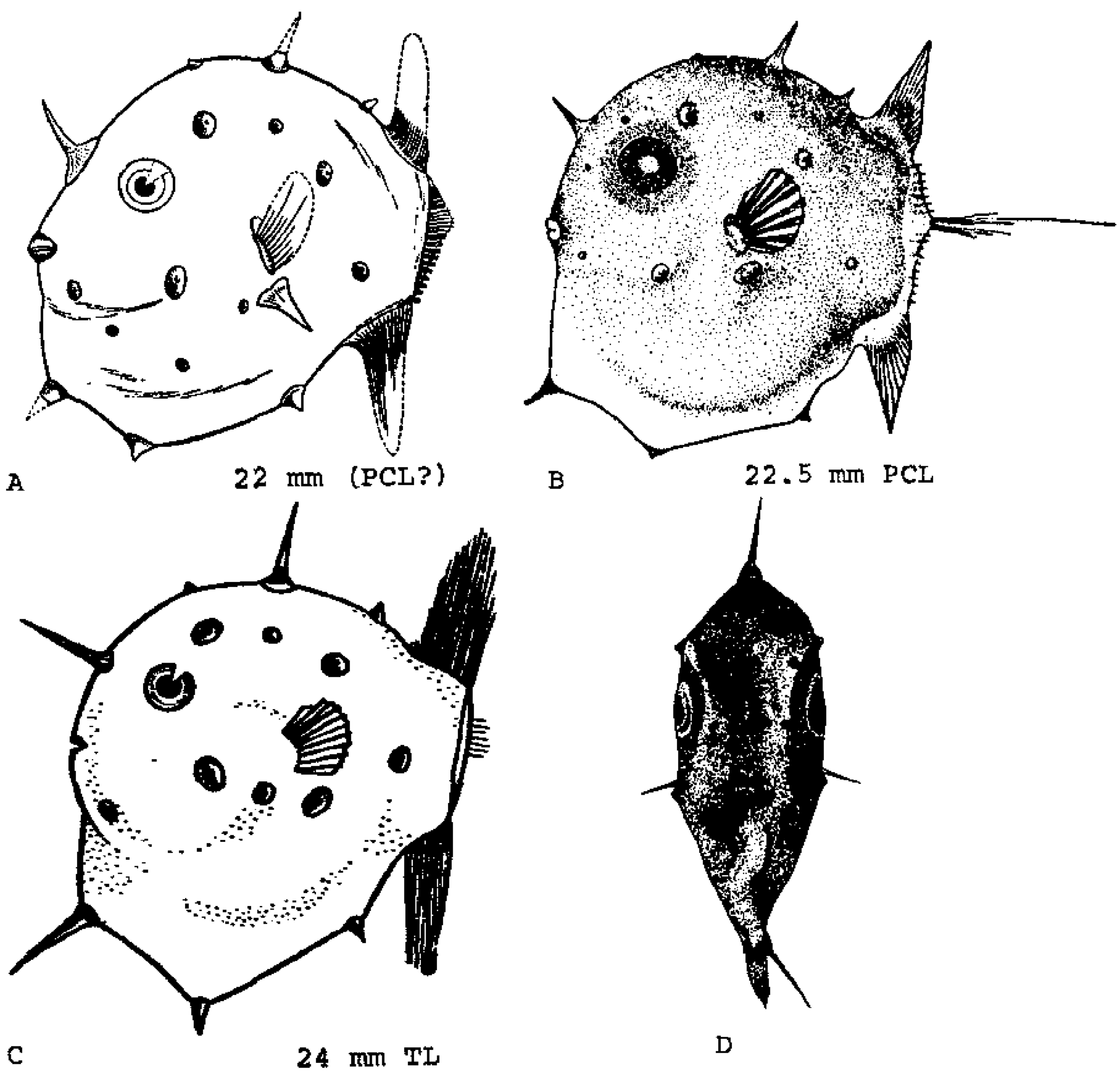

Fig. 165. ***Masturus lanceolatus***, Sharptail ocean sunfish. A. Prejuvenile, 22 mm (PCL?). B. Prejuvenile, 22.5 mm PCL. C. Prejuvenile, 24 mm TL. D. Anterior view of same specimen. (*A, C, Gudger, E. W., 1937a: fig. 12, 20, fig. 20, after Steenstrup and Lütken, 1898. B, Yabe, H., 1953: fig. 1. D, Schmidt, J., 1921b: Pl. 1, fig. 4a, delineated by Tamiko Karr.*)

pectoral with 10 rays, other fin counts obscure, ca. 14 in each of D. and A.; caudal base small, triangular, fleshy *with several, apparently free rays projecting from it; skin* closely studded with microscopic scutes, each one with a more or less distinct central tubercle and radiating striae; skin somewhat rougher on the back and smoother on the sides; 21 enlarged spiniform dermal tubercles [20] (spines), their placement as in smaller specimens; absolute length of longest spines less than 3 mm, as in all Pacific specimens figured here and none of the smaller Atlantic specimens; mouth parts in the form of a beak (GED).

At 12 mm (PCL?; Pacific specimen; description, GED, based on figure [17]) proportions similar to preceding examples, a noteworthy difference is the presence of a long whiplash caudal filament similar to that figured for much larger specimens, this presumably lost in other reported *specimens of comparable size.*

In examples from 20 to 32 mm PCL [3,5,10,11,14] proportions changing little, origin of pectoral fin close to or slightly behind midpoint of PCL; greatest depth of body also near midpoint; depth from origin of dorsal fin to origin of anal fin ca. 50–70% of PCL; distance from tip of dorsal fin to tip of anal fin ca. 100% of PCL. Figure at 22.5 mm PCL [10] and photograph at 25 mm TL [11] (outline traced in the delineation) probably give most accurate representation. An air bladder present at 21 mm TL.[5]

In examples from 34 to 54 mm PCL [3,10,11,12,14,16,24,25] the body becoming longer and deeper behind the pectoral

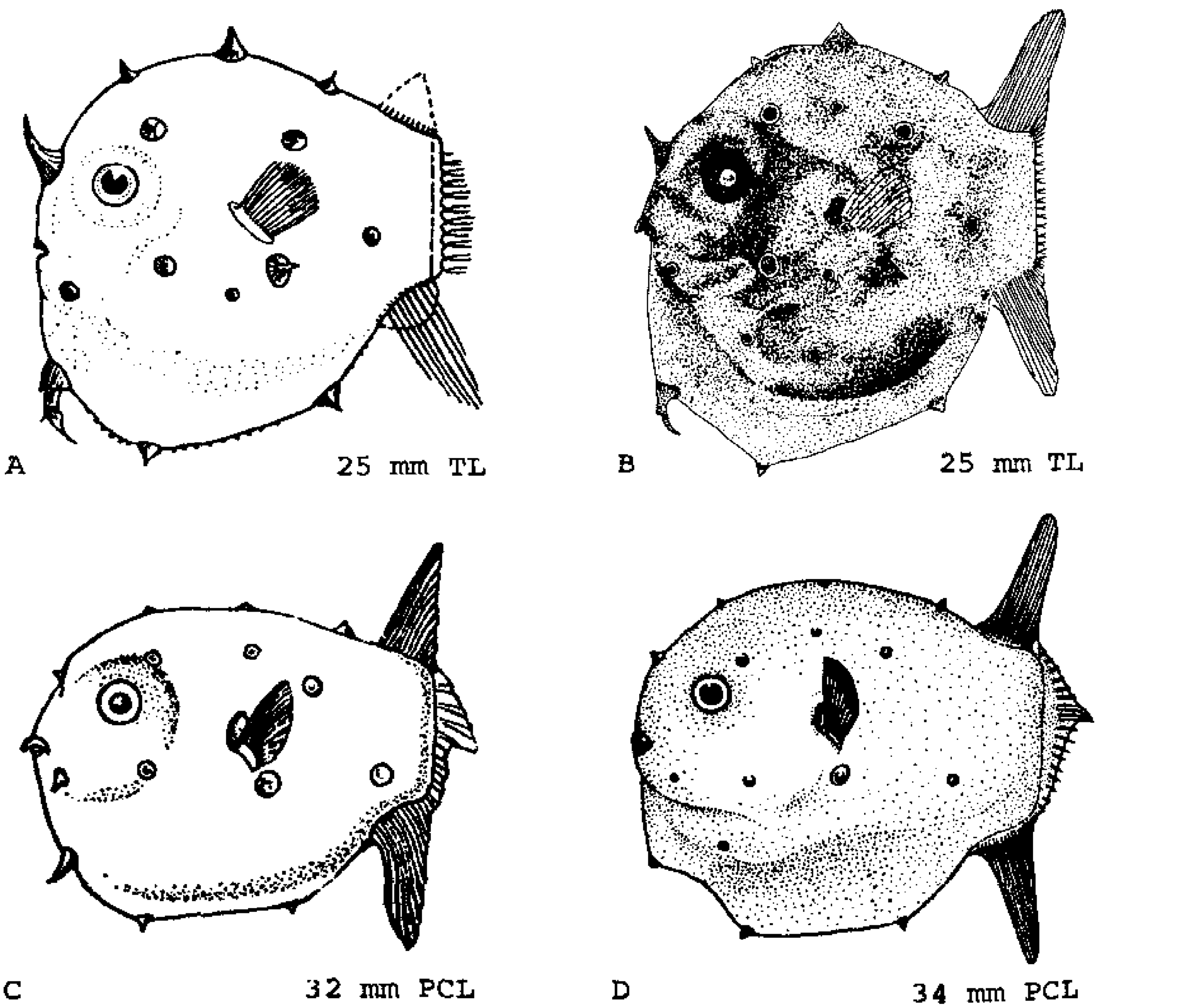

Fig. 186. ***Masturus lanceolatus***, **Sharptail ocean sunfish. A. Prejuvenile, 25 mm TL. B. Another drawing from photograph claimed to represent same specimen (Schmidt, J., 1921b: pl. 1). C. Prejuvenile, 32 mm PCL. D. Prejuvenile, 34 mm PCL. (*A, D, Gudger, E. W., 1937a: figs. 21, 13. B, Schmidt, J., 1921b: pl. 1, fig. 5, delineated by Tamiko Karr. C, Guenther, A. C. L., 1880: fig. 94.*)**

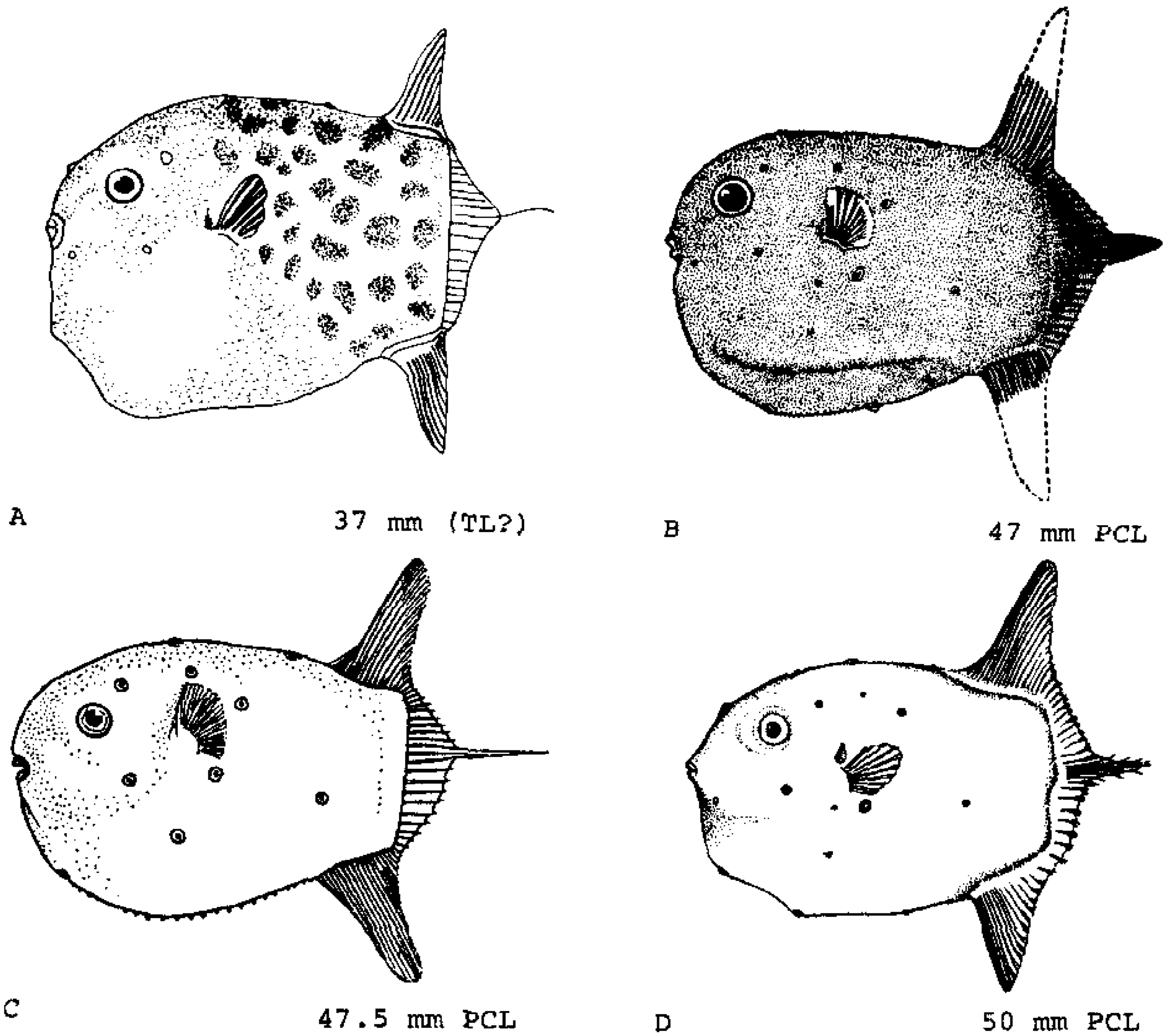

Fig. 167. ***Masturus lanceolatus***, Sharptail ocean sunfish. A. Prejuvenile, 37 mm (TL?). B. Prejuvenile, 47 mm PCL (58 mm TL). C. Prejuvenile, 47.5 mm PCL (ca. 65 mm TL). D. Prejuvenile, 0.50 mm PCL. (*A, Tortonese, E., 1956: pl. 51, fig. 22, redrawn by Tamiko Karr. B, Gudger, E. W., 1935b: fig. 2. C, Gudger, E. W., 1937a: fig. 19, after Steenstrup, J., and C. Lütken, 1898. D, Ryder, J. A., 1886: pl. 7, fig. 5.*)

fins, the depth from dorsal fin origin to anal fin origin increasing relative to the depth at level of pectoral fins;[16,18] clavus widening with development of a fleshy base, its rays projecting beyond the membrane; distance from tip of dorsal fin to tip of anal fin increased considerably in relation to greatest depth of body, although more or less constant *as a percentage of PCL because of* corresponding elongation of the body; spines less prominent (GED) and replaced by scars in specimens 47 and 53 mm PCL;[24] several rows of small spines along ventral edge of body at 54 mm PCL, and a slightly raised dorsal ridge behind midpoint from tip of snout to dorsal fin origin.[23]

Pigmentation: At 13 mm TL grayish above, whitish below in alcohol;[20] specimens 35–50 mm TL silver, black above, with irregularly scattered round dark blotches; vertical fins brown with silver on the claval base.[16]

JUVENILES

Size range not established. Specimens described 60–145 mm PCL (note: specimens ca. 730 mm PCL[36] and 775 mm PCL,[4] the latter figured here as an adult, possibly preadults, *GED*).

In seven specimens: P. 9–10; D. 17–20 and A. 16–19

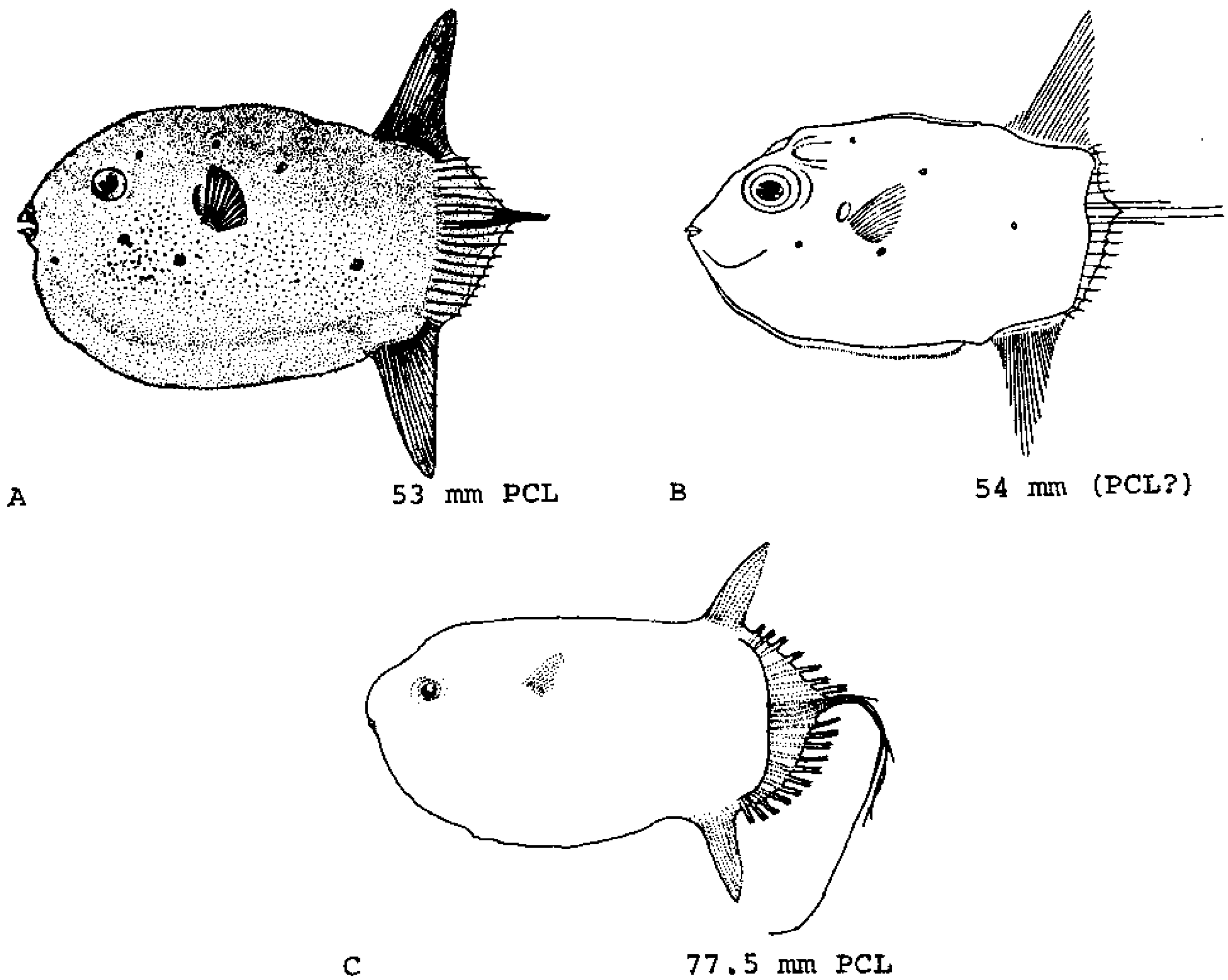

Fig. 168. *Masturus lanceolatus*, Sharptail ocean sunfish. A. Prejuvenile, 53 mm PCL (65 mm TL). B. Prejuvenile, 54 mm (PCL?). C. Juvenile, 77.5 mm PCL. *(A, Gudger, E. W., 1935b: fig. 1. B, Putnam, F. W., 1871b: fig. 3. C, Yabe, H., 1953: figs. 2 and 3, composite drawing by Joan Ellis.)*

(excluding clavus); clavus 19–23 (5–8 dorsal to lobe, 7–12 ventral to lobe, 4–6 in lobe); D. + C. + A. 54–62.[2,8,24,27] Distance from dorsal fin origin to anal fin origin increasing from ca. 60% of PCL at 60 mm PCL [10] to ca. 70% of PCL at 145 mm PCL [27] and from ca. 80% to ca. 100% of greatest body depth over the same size range; prepectoral distance reduced to ca. 40% of PCL by 125 mm PCL; [27] distance from tip of dorsal fin to tip of anal fin variable, ca. 95 [10]–126% of PCL; [8] scars of spines indistinct by 60 mm PCL,[24] not mentioned or figured for larger specimens (GED); several illustrated specimens with fragile, whip-like extensions of the caudal lobe,[8,10,27] these much longer than PCL in two examples 109 and 111 mm PCL; [8] claval rays with multiple dichotomous branching distally,[2,23] but lacking cross striations or articulations.[23]

Pigmentation: In alcohol at 107–130 mm PCL dark gray dorsally,[2,8] light brown on the sides,[2] shading to milky white on the lower two-thirds; gray spots below eyes and pectoral fins and posteriorly above the anal fin;[8] in formalin at 145 mm PCL dark grayish brown dorsally, becoming paler below; with indistinct irregular dark spots of darker shade on the sides, the spots more distinct but smaller toward the ventral margin; dorsal and anal fins similar in color to the upper body and margined by pale (color) on their posterior edges; clavus marked by smaller spots; central process of clavus black almost to its base.[27]

AGE AND SIZE AT MATURITY

Unknown, sexual maturity established by dissection in only one example, a female 2209 mm TL.[40]

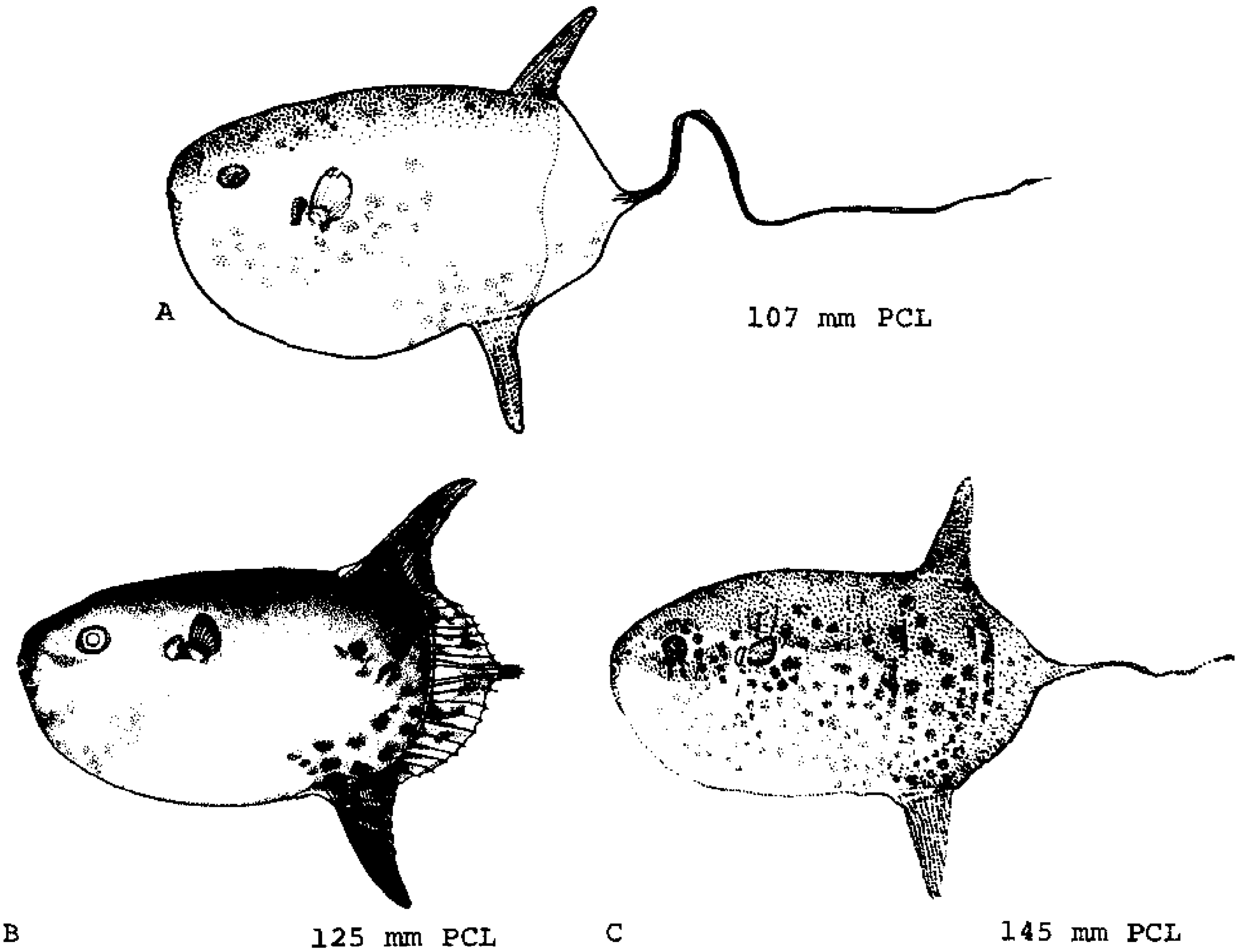

Fig. 169. Masturus lanceolatus, Sharptail ocean sunfish. A. Juvenile, 107 mm PCL (317 mm TL). B. Juvenile, 125 mm PCL (152 mm TL). C. Juvenile, 145 mm PCL (259 mm TL). *(A, King, J. E., 1951: fig. 1, lower fish, delineated by Joan Ellis. B, Gudger, E. W., 1939: fig. 5. C, Kuronema, K., 1940: fig. 2, delineated by Joan Ellis.)*

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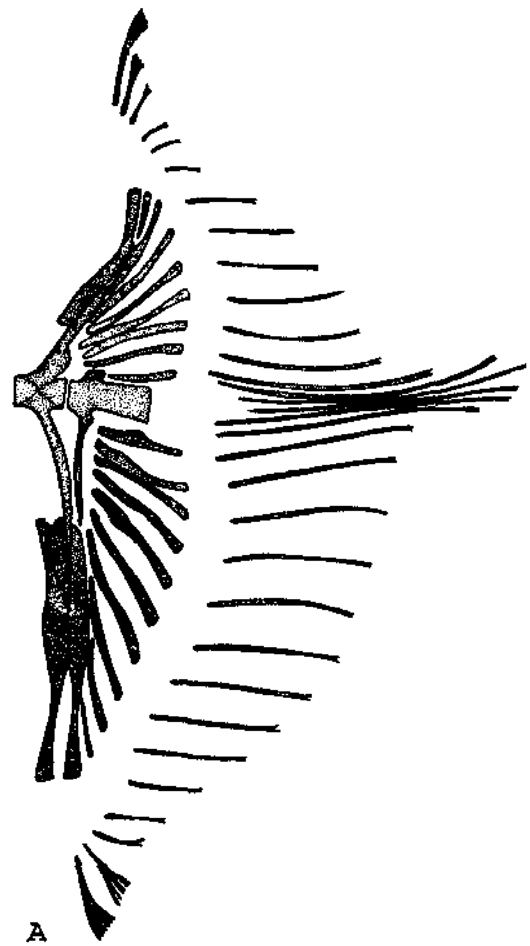

Fig. 170. *Masturus lanceolatus*, Sharptail ocean sunfish. A. Posterior skeleton of juvenile, 127 mm TL, claval rays fully drawn along with a few posterior dorsal and anal fin rays. (*A, Tyler, J. C., 1970: fig. 56, retouched.*)

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Mola mola (Linnaeus), Ocean sunfish

ADULTS

P. 11–13;[4,10,18] V. and C. absent;[2,5,31,56] clavus[5] (pseudocaudal[31,56]) 12,[5] 13[2,18] or possibly to 15[31] (6–7 derived from dorsal fin, 6–8 from anal fin[2,31,56]); total D + A (including clavus) 40–52[2,4,18,37,39] ($\bar{x}$ 47.4,[4] probably higher);[18] D. (excluding clavus) 15–20[4,39] (mode 18[4] or 19[18]); A. (excluding clavus) 14–18[4,39,64] (mode 16[4] to 18[18]); 8–9 bony ossicles at distal ends of claval rays; males with 8–11 distal claval notches;[5,39] vertebrae 17[40,41,64]–18[41] (8 + 9, JCT, 9 + 8,[5] 10 + 7[65]); gills 4; branchiostegals 6.[5,61]

Range of proportions as percent of TL: Distal tip of dorsal fin to distal tip of anal fin 98.5[55]–137.0[22] (greater in females, decreasing with increasing total length in both sexes[8,18,21,22,23,46,55]); body depth (dorsal fin origin to anal fin origin where stated) 50.7[18]–65.0[22] or 77.8 (newspaper account, questionable);[18] prepectoral 27.8[46]–39.2;[22] predorsal 51.8[8]–67.0;[22] preanal 54.0[8]–70.7;[23] pectoral fin length 9.2[18]–15.0;[22] dorsal fin height 37.5[22,46]–43.0;[16] anal fin height 34.5[16]–42.0; pectoral fin base 7.1[22]–9.4; dorsal fin base (excluding clavus) 18.8 (female)[21]–26.1 (male);[46] anal fin base (excluding clavus) 15.7 (female)[21]–23.8 (male);[18,46] head 25.0[46]–30.0;[22] snout ca. 11.6 (female)[21,61]–ca. 15.4 (male);[23] eye 2.8–4.2[18] (axis unstated), on longitudinal axis 3.6[21]–4.9,[61] vertical axis 3.1[12,61]–4.0;[61] diameter of gill opening 3.0[22]–6.3 (axis unstated);[22] width of mouth 6.8;[46] horizontal length of clavus 8.9[61]–22.0.[19]

Body strongly compressed,[39] ovate[38] or elongate-elliptical,[46] truncate behind, lacking a caudal peduncle;[30] ventral profile subhorizontal, carinate or keel-like from below pectoral fin origin to just ahead of vent.[2,16,46] Snout overhanging mouth,[39] nearly vertical in females but projecting in males;[5] skin of snout hardened,[2] often with an osseous tubercle at tip;[21,37,54] chin deeply rounded; broad supraoccipital ridge extending from snout back over eye, less pronounced ridge on cheek extending back below pectoral fin; eye located in the broad, shallow groove between these ridges[46] near midpoint between snout tip and pectoral fin base; eye oblong, with its major axis longitudinal and very moveable in its orbit,[16,46] with well developed nictitating membrane;[2] nostrils small, double, with circular lips, located behind a deep sulcus[46] near eyes;[16] mouth very small;[40] teeth of adults completely united in each jaw,[1,38,39] forming a bony beak without noticeable sutures;[38,46] premaxilla without ascending processes, suturally joined to maxilla,[2] not protractile; palatines immovable,[1] toothless;[17] tongue broad, thick and rounded;[46] fourth pharyngeal toothed;[1] first branchiostegal not enlarged;[16] sixth branchiostegal noticeably smaller than the others;[2,22,61] gill rakers concealed in thick skin;[66] inner and outer gill openings reduced to small slits less than one-fifth as long as the gills; outer gill opening just ahead of pectoral fin,[2] but separated from it by a strip of roughened skin;[66] opercular bone much reduced;[2] pseudobranchiae present.[17] Pectoral fins relatively short, rounded;[12] no pelvic girdle or pelvic fins;[39] dorsal and anal fins subequal,[46] lacking spines,[38] both fins originating about midway between gill opening and posterior tip of clavus,[17] actually confluent at end of vertebral column but divided functionally into three fins;[5,31,56] vertical portions with long, muscular bases that furnish power for locomotion,[5,14] the bases lengthening somewhat with age even in adults, and close-set rays almost obscured from view by thick integument;[5] vertical portions set off by notches from the rudder-like clavus,[2,5] or pseudocaudal,[31] which functions in steering; claval rays slender,[5] lacking cross-striations or articulations,[31] their distal ends branched and hyperossified in adults into bony plates or ossicles; the paraxial (lower dorsal and upper anal) rays joining distally in a single ossicle (a feature said to distinguish *Mola mola* from *M. ramseyi*); five median claval lobes of larger males elongated well beyond the ossicles.[5] Rigidity of the body maintained by a thick, elastic, very tough collagenous hide;[5,39] integument of hide and fins composed of close-set polygonal scutes (about 4 per cm on cheeks of adults), each with a rugose central spine[46] projecting straight outward ca. 1 mm,[2] or up to 2 mm on the head over eyes;[21] longitudinal folds sometimes present in skin;[60,61] scutes covered with a characteristic layer of thick, persistent mucus;[15] scutes arranged in rows on dorsal and anal fins, and less noticeable in a band of flexion from dorsal fin origin around clavus to anal fin origin.[5] Adults lacking an air bladder;[12,38,40] skeleton poorly ossified, mostly cartilagenous except in jaws and fin rays;[2] also lacking typical teleostean otoliths, the maculae containing instead aggregations of small, white, rounded otoconia;[26] ovary single.[67]

Pigmentation: Gray, olive gray or blackish with a brown cast dorsally; sides paler with silvery reflections,[12,16,33,39] small round or elliptical bright spots on sides of male;[23] dusky to dirty white ventrally[16,37,38] band of flexion along bases of median fins conspicuously darker or lighter than surrounding areas in some specimens, inconspicuous in others;[21,23] median fins colored like adjacent part of body,[16] blackish;[64] lips and area around nostrils black; inside of mouth pinkish; teeth dirty white;[46] pupil of eye in life black[16] or dark milky blue;[46] iris brownish or smokey with an inner silver ring around pupil.[16,46]

Maximum size: Claimed to reach 4000 mm;[30] record may be 3327 mm (California);[55] Mediterranean records to 2800 mm (Italy);[29] in western Atlantic 2438 mm (North Carolina).[50,57]

DISTRIBUTION AND ECOLOGY

Range: Oceanic and cosmopolitan, reaching the Gulf of St. Lawrence, Newfoundland, southern Iceland, northern Norway and the Kola Peninsula in the Atlantic; the southern Kuriles and the Gulf of Alaska in the Pacific; in the southern hemisphere to the Cape of Good Hope and possibly the coast of Chile; [13,25,39] in the Mediterranean Sea,[5,29] and the Gulf of Mexico to Texas.[33,49] Somewhat rare in the tropics; [13,38] reported from tropical west Africa, Ceylon, Mexico and the central Pacific.[13] Sporadically abundant in summer and fall inshore in central California [47,52] and Italy [29] (sightings numbering in the hundreds for a season).

Area distribution: Scattered reports, fairly regular in occurrence off New Jersey,[50] never common in the mid-Atlantic area, but reported even from inside Sandy Hook, New Jersey,[37,62] and Isle of Wight Bay, Maryland.[42]

Habitat and movements: Adults—known to occur in the epipelagic zone of the oceanic environment; [5,6,13] usually seen idling at or near the surface, but a few reports of capture with trawl [53] and baited lines [30,50,53,58,60] indicate a considerable range of depth distribution in waters up to 3750 m deep; [53] details of habitat and movements largely conjectural; [5] seasonal appearance, usually in conjunction with coelenterates and ctenophores characteristic of certain ocean currents [6,27,44,45,48,63] has been taken as evidence that major movement is passive transport by currents,[6,24,44] but also of active feeding migrations.[28,63] Adults of *Mola* sp. reported to often travel in pairs,[46] sometimes in groups.[12]

Larvae—one of two putative *Mola* larvae taken in sample with an unidentified istiophorid larvae off the east coast of Brazil,[9] the other in the Straits of Messina between Italy and Sicily,[35] no other data.

Prejuveniles—capture data unstated or vague for most, some from stomachs of *Coryphaena* or similar predatory fishes,[20,59] one relatively undigested in an albacore taken on a longline at 182 m depth,[59] another washed aboard a ship [51] was obviously near surface; Atlantic [20,32,36,51] and Pacific [28,59] records from outer circulation in areas of currents, i.e., Gulf Stream and Kuroshio, not common with *Masturus* and *Ranzania* in doldrum areas such as Sargasso Sea.[52]

Juveniles—small individuals 600–900 mm TL (classified as young adults by Fraser-Brunner [5]) entering Monterey Bay, California in some numbers during summer, their occurrence possibly correlated with large influxes of jellyfishes; reported to swim actively at a depth of 1.8 m or slightly less in water 7–15 m deep, occasionally to break or even clear the surface, but not to swim at surface with projecting dorsal [46] (leaping behavior also reported earlier [52]); no data on temperature and salinity tolerances for any stage of life cycle (GED).

SPAWNING

Location: No direct information; from distribution of young assumed to be in outer circulation of temperate Atlantic [9,20,32,36,51] and Pacific oceans [28] and in Mediterranean Sea; [35] apparently not in Sargasso Sea; [32] in western Pacific south of 30° N and east of 130° E.[28]

Season: No direct information; prejuveniles 8–12 mm TL taken south of Japan in March, August and September; [28] Brazilian larva January or February; [9] a male 1260 mm TL taken in New Jersey in September was unripe.[62]

Temperature and salinity: No information.

Fecundity: A female 1500 mm TL was estimated to contain no fewer than 300 million eggs; [34] ovary weighed 4.5 kg in a female 2230 mm TL.[21]

EGGS

Location: No information.

Unfertilized eggs: Ovarian eggs, probably immature, measured 0.42–0.45 mm in diameter.[25]

Fertilized eggs: No information.

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information; [5] stage short in duration in most tetraodontiform fishes (FDM).

LARVAE

Specimens described 1.42 [9] and 1.84 mm TL [35] (putative *Mola mola* larvae). Length at end of stage not established, probably similar to *Masturus* (ca. 3 mm, GED).

At 1.42 mm TL globular carapace-like hide covering body back to level of the anus; caudal trunk well differentiated with ca. 12 postanal myomeres; finfold continuous from the dorsal edge of carapace to the anus, somewhat constricted posteriorly; pectoral fins developed, not reaching anus, shown with 13 rays (doubted that the rays this distinct, GED); a suggestion of first mid-dorsal spine as a frontal protuberance at level of dorsal edge of eye; second and third mid-dorsal spines longer, differentiated; no sign of a fourth mid-dorsal spine; two paired spines indicated over eyes, the anterior pair directed forward and somewhat longer than the posterior pair; two or three mid-ventral protuberances, the anterior one directly below eye. If figure proportioned accurately preanal length is slightly greater than postanal length.[9]

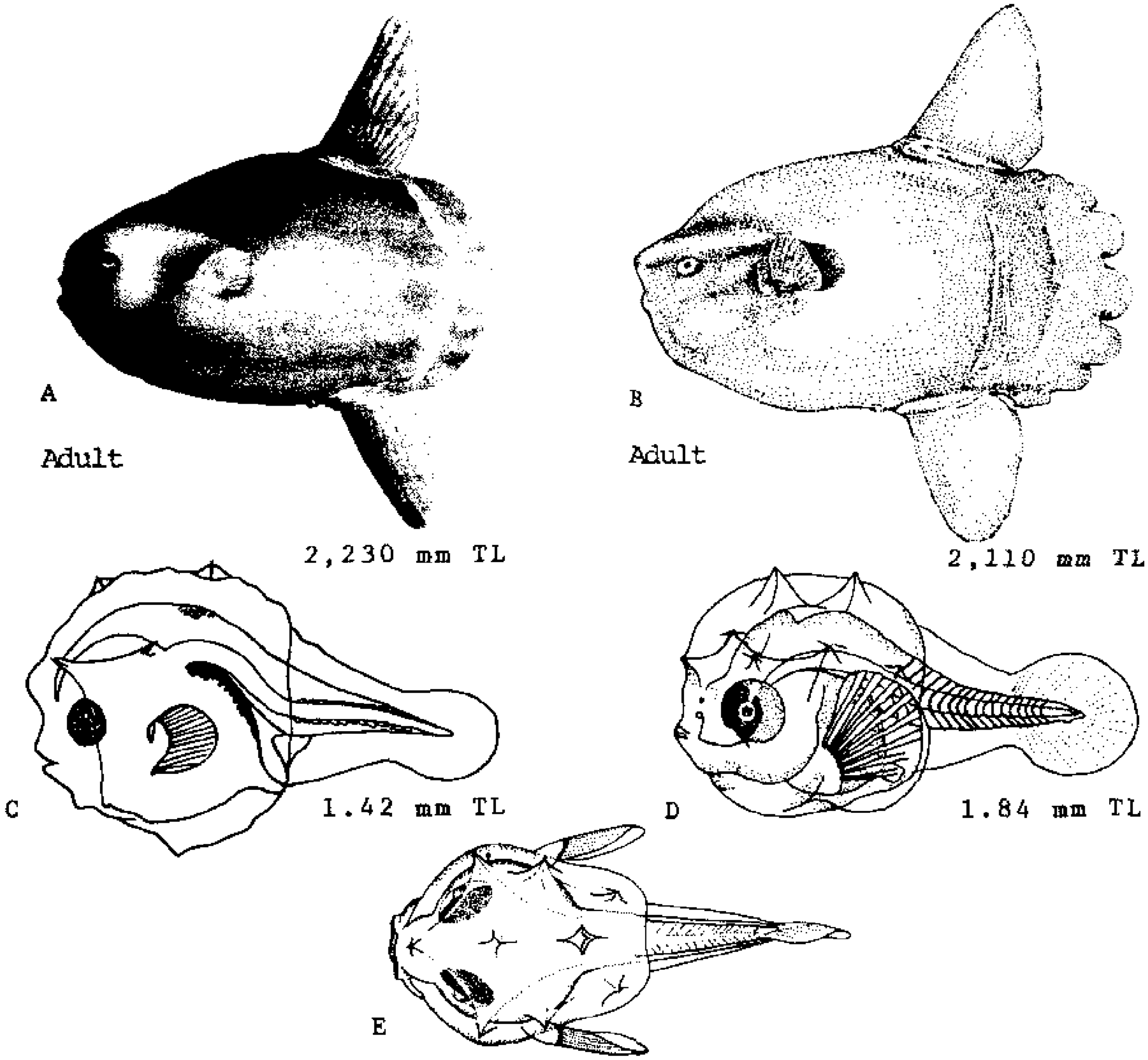

Fig. 171. *Mola mola,* Ocean sunfish. A. Adult female, 2230 mm TL, horizontal fold in clavus probably atypical. B. Adult male, 2119 mm TL. C. Putative *Mola mola* larva, 1.42 mm TL. D. Putative *Mola mola* larva, 1.84 mm TL. E. Dorsal view of same specimen. *(A, Lidth de Jeude, T. H., van, 1872, pl. 8. B, Murray, J., and J. Hjort, 1912, fig. 102, delineated by Joan Ellis. C, Aboussouan, A., 1969: fig. 10. D, Tortonese, E., 1956: fig. 828, reversed, after Sanzo, L., 1939: fig. 16, caudal region redrawn from original. E, Sanzo, L., 1939: fig. 17, redrawn by Joan Ellis.)*

At 1.84 mm TL carapace extending somewhat posterior to anus; nares formed and double; caudal trunk still distinct, total myomeres 17; finfold continuous with striations radiating from urostyle; no evidence of dorsal or anal fin formation; pectoral fins well developed, extending behind anus, with 8 rays differentiated in the dorsal two thirds, ca. 4 developing ventrally; three mid-dorsal spines differentiated, with second and third longer than first; still no indication of a fourth mid-dorsal spine; two paired spines over eyes, the anterior pair shown as longer and higher than the posterior pair and evidently obscuring the latter in dorsal view; two more paired spines differentiated above the level of the pectorals, one over the pectoral origin, the second behind and slightly below it over the anus; no paired or unpaired spines shown below a line from mouth to urostyle. Preanal length about equal to postanal length.[35]

Pigmentation: In both specimens described dark pigment is shown along dorsal side of gut;[9,35] at 1.42 mm an additional patch figured mid-dorsally under carapace above pectoral fin origin.[9]

PREJUVENILES

Specimens described 5–59 mm TL. End of stage not

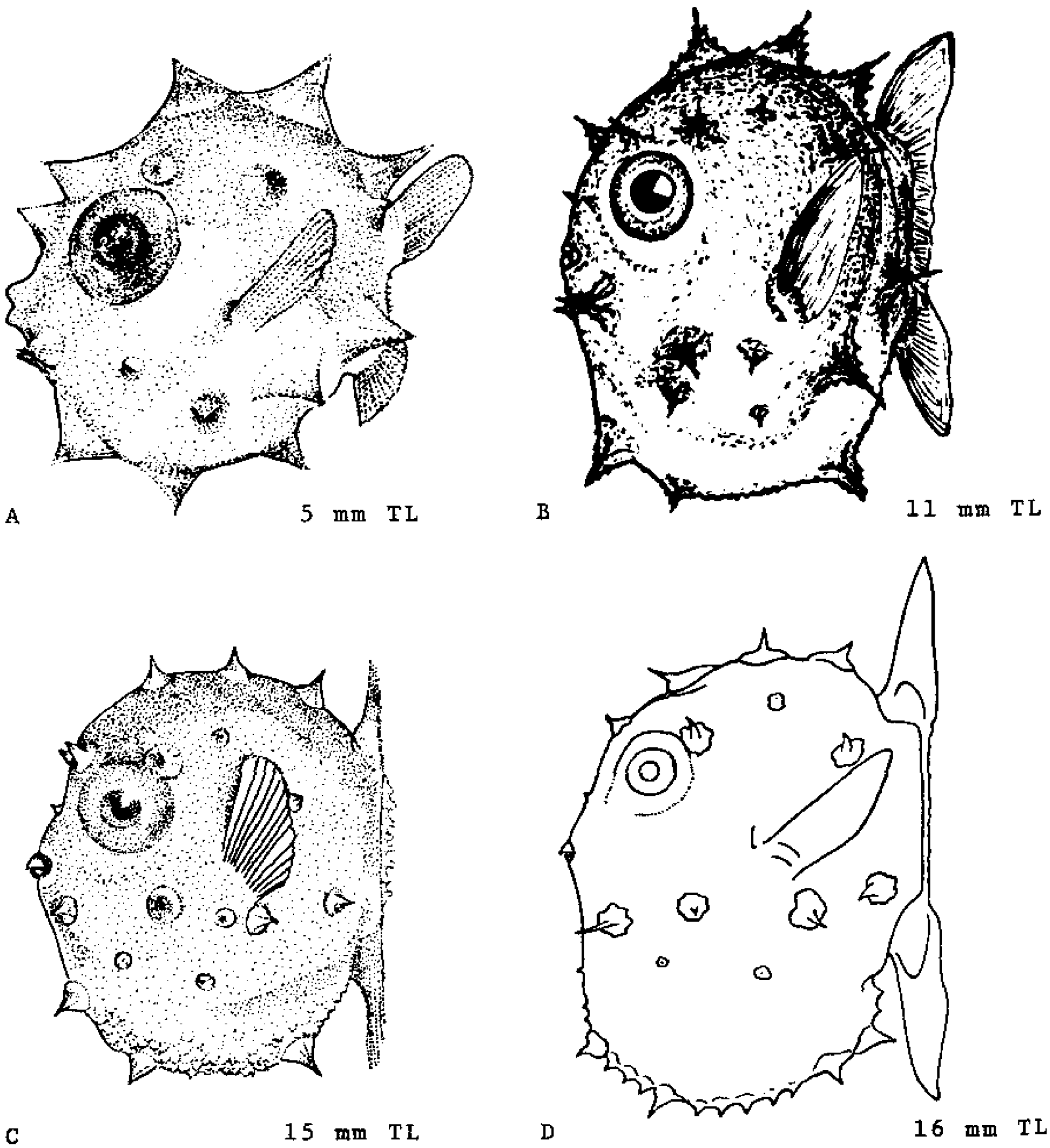

Fig. 172. *Mola mola*, Ocean sunfish. A. Prejuvenile, 5 mm TL. B. Prejuvenile, 11 mm TL. C. Prejuvenile, 15 mm TL. D. Prejuvenile, 16 mm TL. (*A, Schmidt, J., 1926, fig. 1, delineated by Joan Ellis. B, Sokolovskaya, T. S., and A. S. Sokolovskiy, 1975: fig. 2g. C, Steenstrup, J., and C. Lütken, 1898: pl. 4, fig. A and Schmidt, J., 1921b: pl. 1, fig. 1, reversed, redrawn by Joan Ellis. D, Fraser-Brunner, A., 1951: fig. 15b.*)

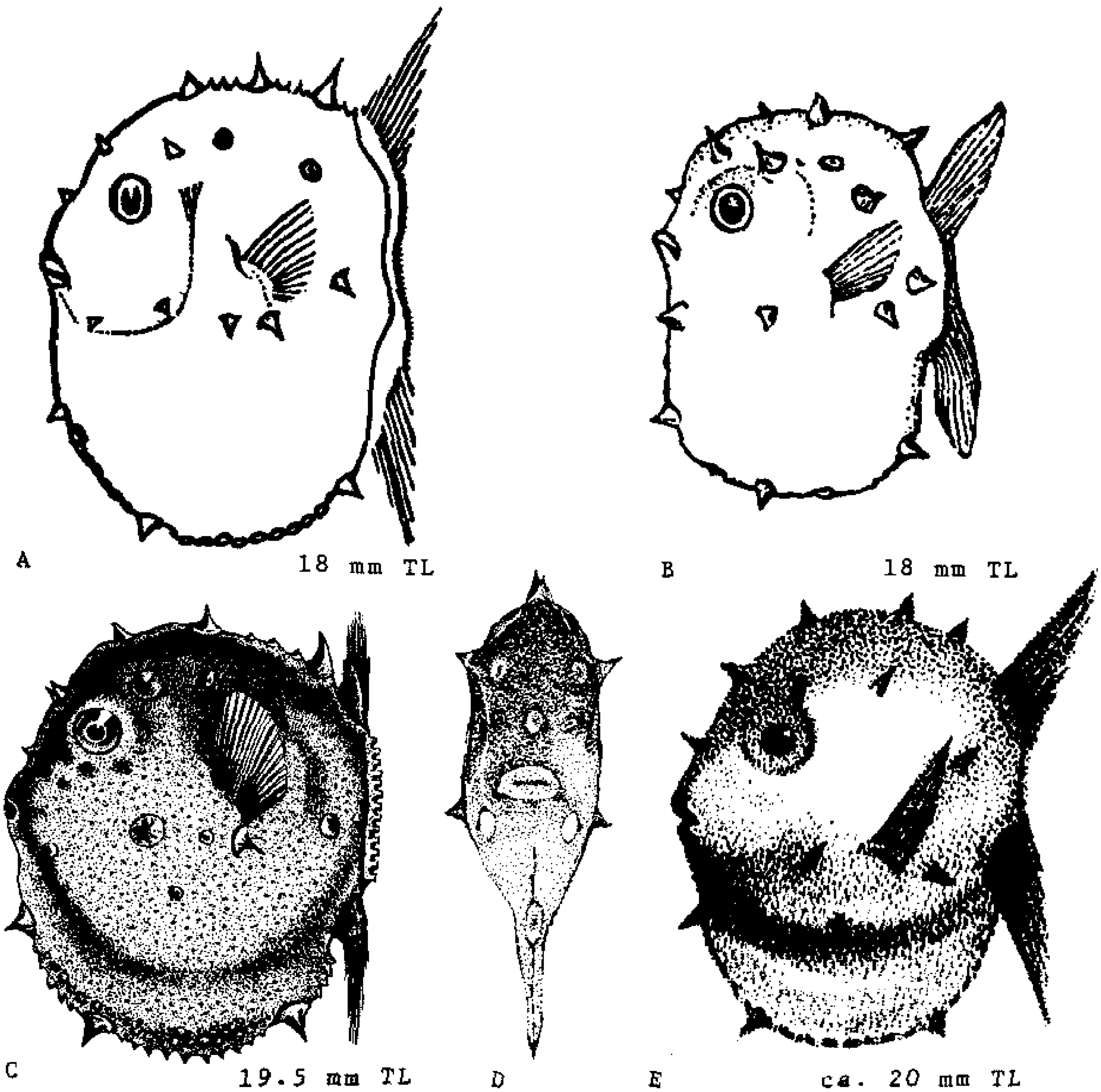

Fig. 173. ***Mola mola***, Ocean sunfish. A. Prejuvenile, 18 mm TL. B. Prejuvenile, 18 mm TL. C. Prejuvenile, 19.5 mm TL (length stated in Schmidt, J., 1921b). D. Anterior view of same specimen. E. Prejuvenile, ca. 20 mm TL. (*A, Putnam, F. W., 1871a: fig. 1 and 1871b: fig. 132, reversed. B, Ryder, J. A., 1886: pl. 8, fig. 2, after Guenther, A., 1880. C, Poll, M., 1947: fig. 261, reversed, after Steenstrup, J., and C. Lütken, 1898. D, Schmidt, J., 1921b: pl. 1. fig. 2a, delineated by Joan Ellis. E, Mitchell, S. L., addendum to 1828: pl. 5, see family introduction.*)

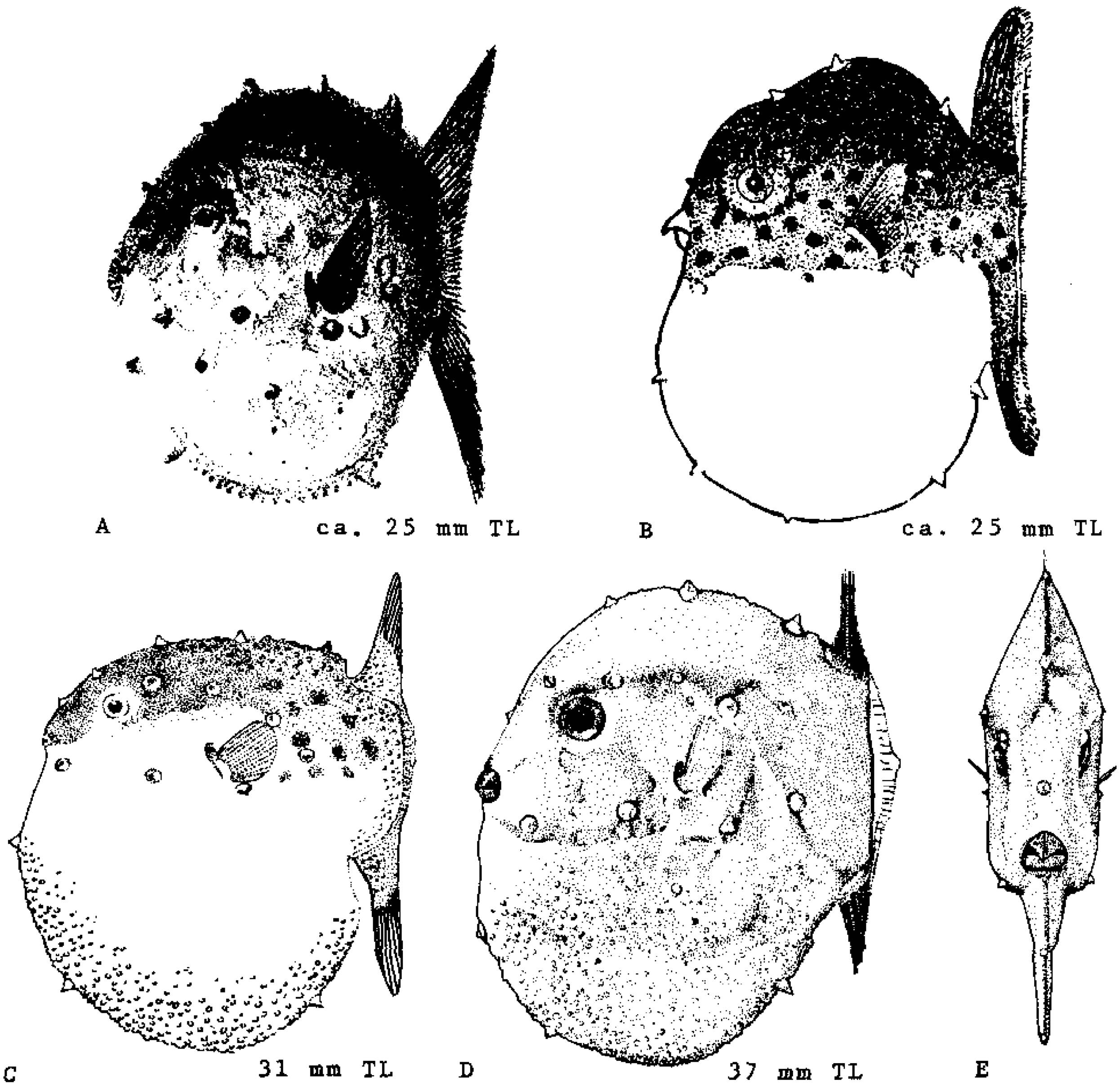

Fig. 174. *Mola mola*, Ocean sunfish. A. Prejuvenile, ca. 25 mm TL. B. Prejuvenile, ca. 25 mm TL. C. Prejuvenile, 31 mm TL. D. Prejuvenile, 37 mm TL. E. Anterior view of same specimen. (*A, de Kay, J. E., 1842: fig. 179, reversed. B, Smith, J. L. B., 1965: fig. S. C, Tortonese, E., 1956: pl. 51, fig. 20, redrawn by Joan Ellis. D, E, Reuvens, C. L., 1894: pl. 5 and Schmidt, J., 1921b: pl. 1, fig. 3, redrawn by Joan Ellis.*)

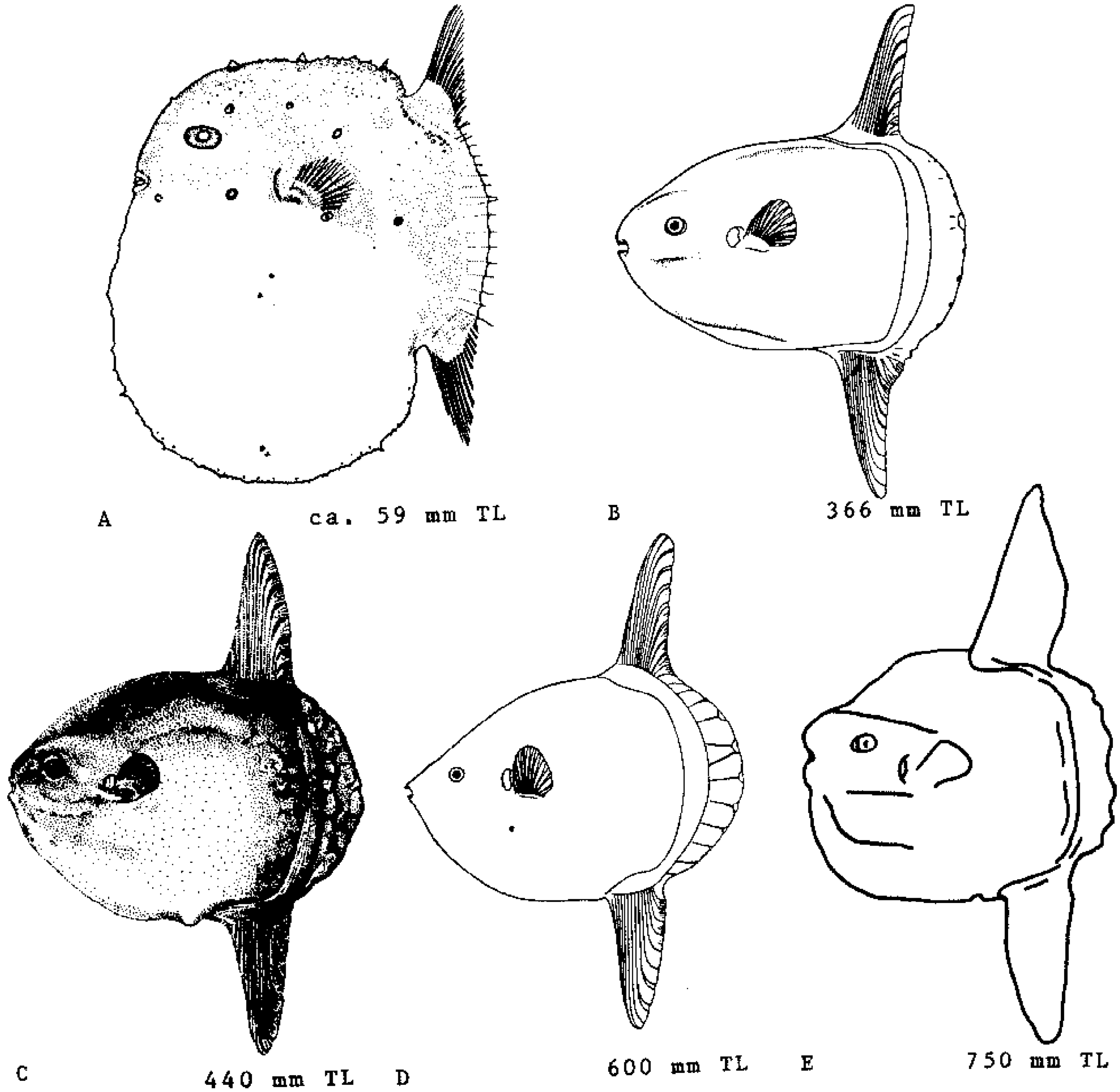

Fig. 175. *Mola mola*, Ocean sunfish. A. Prejuvenile, ca. 59 mm TL, 53 mm PCL. B. Putative juvenile, 366 mm TL. C. Putative juvenile, 440 mm TL. D. Putative juvenile, 600 mm TL. E. Male, 750 mm TL, probably immature. (*A, Koronuma, K., 1940: fig. 1. B, D, Fraser-Brunner, A., 1951: figs. 17, 16. C, Steenstrup, J., and C. Lütken, 1898: pl. 3, redrawn by Joan Ellis. E, Roon, J. M., van, 1942: fig. D.*)

established; before 50 [64] or 60 mm TL [59] greatest depth usually exceeds total length. Later spines are lost or transformed to osseous tubercles,[37,54] and proportions and development of clavus approach the adult configuration.[1,5,10,61]

At 5 mm TL (description, GED, based on photograph,[39] see family introduction for divergent interpretations) carapace globular and spinose in lateral view; eye proportionately very large, ca. 30% of TL; body truncate behind carapace, without discernible caudal peduncle or caudal fin; dorsal and anal fins present, with evidence of ossified rays (counts not stated); all 23 numbered spines (see family introduction for numbering system) apparently present, plus at least one unnumbered pair between spines 11 and 13; posterior three mid-dorsal spines (2–4) and all three mid-ventral spines (5–7) about the same length; all spines shorter than the eye diameter (diagnostic for the species at this and larger prejuvenile sizes).

At 11.0 mm TL (description, GED, based on illustration [28]) body deeper than in preceding description, greatest depth ca. 125% of TL; eye smaller in proportion, ca. 23% of TL; a narrow clavus evident; dorsal and anal fins more widely spaced; pectoral fin base located behind midpoint of body; all numbered spines present plus an unnumbered spine between spines 11 and 13, a second below it, and a third below spine 11; anterodorsal eye spine 17 about same size as posterodorsal eye spine (no. 19) (also species diagnostic at this and larger prejuvenile sizes).

At 15 mm TL (description, GED, based on illustration [4] and photograph [10] of same specimen) mouthparts have formed the characteristic beak; distance from tip of dorsal fin to tip of anal fin almost equal to greatest depth of body; spines somewhat shorter in proportion than in preceding figure; number and placement of spines essentially identical to the preceding figure. No significant differences evident at 16 mm TL (GED, based on illustration [5]); only two unnumbered spines figured.

At 18 mm TL (based on two early illustrations [20,43]) and 19.5 mm TL (based on illustration [4] and photograph [10] of same specimen) the eye still smaller in proportion, 10–12% of TL; the mouth also smaller; unnumbered spines in figures vary from none to two (GED).

Figures at ca. 20 [51] and ca. 25 mm TL [7] are included mainly for historical interest; they appear reasonably accurate for their time. Smith's figure at ca. 25 mm TL [11] omits several lateral spines and includes five mid-ventral spines, two more than any other figure.

At 31 mm TL [36] and 37 mm TL (description, GED, based on illustration [54] and photograph [10] of same specimen) greatest depth has decreased to 113–114% of TL; eye diameter to 8–10% of TL; distance from tip of dorsal fin to tip of anal fin has increased to 112–122% of TL; pectoral fin base now located at about midpoint of total length. Both illustrations indicate the development of integumentary scutes. The 37 mm TL specimen exhibits a median suture between the upper jaw halves;[54] a 40 mm TL specimen was reported to possess median sutures in both upper and lower jaws.[21]

At ca. 59 mm TL (from scale in figure, also stated to measure 53 mm PCL) greatest depth ca. 117.8% of TL; tip of dorsal fin to tip of anal fin ca. 126% of TL; maximum body width (behind eye) ca. 22% of TL. Meristics: P. 11; total D. + A. 53; D. (excluding clavus) 19; A. (excluding clavus) 17. Skin smooth to the touch, but dorsal and ventral edges serrate, the ventral edge more strongly so; remnants of larval spines (figured as small spines but described as scars), 3 on dorsal midline, 2 on ventral midline, and 7 lateral, with 3 above pectoral and 4 below pectoral in oblique series; clavus fleshy but very thin, clearly demarked from body, body wedge-shaped in both anterior and dorsal view; oval shape of left eye stated to be a preservation artifact.[59]

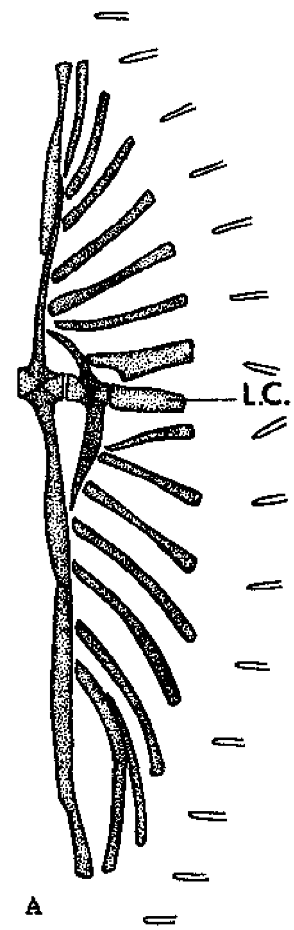

Fig. 176. *Mola mola*, Ocean sunfish. A. Posterior skeleton of putative juvenile 305 or 310 mm TL, only positions of claval ray bases indicated, L.C. is last vertebral centrum. (*A, Tyler, J. C. 1970: fig. 55.*)

Pigmentation: Skin silvery at ca. 18 mm TL;[20,43] olive brown dorsally and silver white on the sides and belly at ca. 20 mm TL;[51] in alcohol brownish above, silver below the level of the pectoral fins, with round dark spots, more or less distinct on the posterior part, at 31 mm TL;[36] colors faded in alcohol but grayish dorsally, colorless on abdomen and fins at 53 mm PCL.[59]

JUVENILES

Size range: Not established. Size range of described specimens provisionally classified as juveniles: 305–750 mm TL.

Most obvious difference between illustrated examples[4,5,61] and prejuveniles is a posterior shift of the deepest part of body from the level of the pectoral fin origin to the level of the dorsal fin origin. Body profile in this size range more nearly circular than that of larger examples, greatest depth 58[4]–87% of TL[61] ($\bar{x}$ 66.3 for a sample of 16[4,5,61]); distance from tip of dorsal fin to tip of anal fin also greater in proportion to total length, 131[4]–153% of TL[61] ($\bar{x}$ 144.7 in same sample).

At 366 mm TL bony ossicles figured as distal small buttons at end of claval rays,[5] these not mentioned for 305 mm or 310 mm PCL examples, whose rays were stated to branch in a single dichotomy distally.[31] Example at 750 mm TL the smallest exhibiting scalloped claval margin and elongated snout typical of larger males; this specimen, identified as a male, had pronounced ridges above and below eye, a very deep body (greatest depth 86.7% of TL), and high median fins (distance from tip of dorsal to tip of anal 153% of TL), or, conversely, an unusually short body.[61]

Pigmentation: Becoming progressively more uniform, with loss of bright silver ventrally and spots and brown variegations.[12,36]

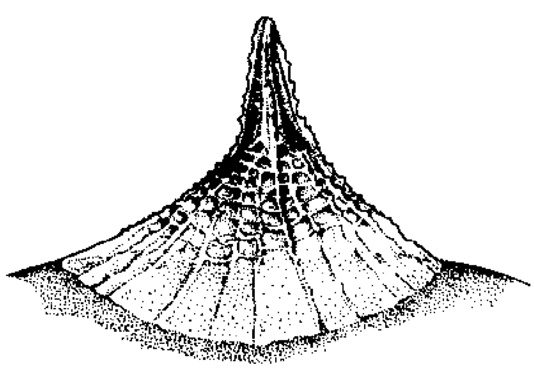

Fig. 177. ***Mola mola*, Ocean sunfish.** Details of third mid-dorsal spine of a 14 mm TL prejuvenile (USNM 217452). (*Original drawing by Joan Ellis.*)

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information on age. Sexual maturity reported for only a few animals, i.e., a male 1194 mm TL,[2] females 1372[5] and 2230 mm TL;[23] Fraser-Brunner's undocumented designation of specimens less than 1000 mm as adult[5] questioned (GED).

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Opsanus tau
Porichthys plectrodon

toadfishes
Batrachoididae

FAMILY BATRACHOIDIDAE

The toadfishes and midshipmen are bottom dwelling fishes primarily nearshore in tropical and temperate waters. They are distinguished by having large heads, wide mouths, 2–4 dorsal spines, long soft dorsal and anal fin bases and broad pectoral fins. Breder and Rosen (1966) indicate that all batrachoidids for which the eggs and spawning habits have been described have demersal eggs which the fish attach to the underside of projecting objects and which are cared for by the male parent.

Batrachoidids do not appear to have a pelagic stage and, therefore, their movements are restricted mostly to the bottom. Distribution patterns are probably greatly effected by this fact. Despite the short distance between mainland Florida and Little Bahama Bank (about 70 km), *Opsanus tau* from Florida has apparently not become established in the Bahamas (Böhlke and Chaplin, 1968). While there is a possibility that the reasons for this phenomenon are unrelated to motility, the tropical batrachoidids are conspicuous in their absence from, or rarity within, the West Indies.

The use of the name *Porichthys plectrodon*, Jordan and Gilbert, here follows Gilbert and Kelso (1971), supporting the observations of Fitch and Brownell (1971), except that Jordan and Gilbert are credited as the authors instead of Goode and Bean (see synonymy in Hubbs and Schultz, 1939).

Opsanus tau (Linnaeus), Oyster toadfish

ADULTS

D. (II [33]) III–24 [22,33] to 28; [27,28] A. 20 [33]–23 [24] or 24; [22,27] C. 2+7+7+2; [24] P. 19–21; [33] V. I, 2 or 3; [26] scaleless; [22,23,27] vertebrae 11+23 [2,24]–24=34–35; [24] gill rakers 11 fleshy tubercles; [26] teeth blunt, conical [33] in a single row on jaws, vomer and palatines; [22,32] branchiostegals 6.[26]

Body proportions as percent TL: Head length 32.8–37.7; [23] depth 20 [22]–28.2. *Proportions as percent HL:* snout 20.0–25.6; eye 20.2–29.0; interorbital width 7.8–15.3; [23] mouth width 70.0.[26]

Body robust,[23,27] anteriorly depressed, posteriorly compressed; [23] head large, flat with rounded snout; [28] maxillary reaching well behind eye.[23] Lateral line obscure,[22,23] bifurcate in vicinity of pectoral girdle, dorsal branch backward below the base of dorsal fin, ventral branch above base of anal.[13] First dorsal fin inserted at back of head; deep notch between dorsal fins; [28] second dorsal fin long, of about uniform height; [23] caudal fin rounded; [23,28] anal fin inserted under 8th dorsal ray,[28] long, distal ends of rays more or less free; [43] pelvic fins jugular; [43,48] pectoral fin broad, fan-shaped.[43] Numerous flaps or cirri on head.[42,43] Opercle with 2 concealed spines,[42,53] subopercle with 1 stiff spine above which is a *long, thin, flexible spine, not apparent without dissection.*[53]

Pigmentation: Some ability to alter coloration.[20,48,54] Back, sides and head greenish, brownish [42,48,54] or yellowish; [48,54] blackish [42,53] or brownish reticulations or mottlings; [53] belly and underside of head yellowish; numerous small, pale yellowish or whitish spots on sides; [42] darker markings variable, occasionally restricted to head and fins or may sometimes even be on belly; [48] soft dorsal and anal fins with 5–9 irregular black bands, caudal, pectoral and pelvic fins with 5–7 similar but more sharply-defined cross bands.[42]

Maximum length: Reported to reach 381 mm [42,43,47,48] but largest measured specimen 368 mm.[54] Very few longer than about 305 mm.[48]

DISTRIBUTION AND ECOLOGY

Range: Massachusetts to Cape Sable, Florida, some intergradation with *O. beta* in Biscayne Bay region; [23] 2 records north of Cape Cod.[28]

Area distribution: Throughout Chesapeake Bay except fresher waters [12,27] and Atlantic coasts of Virginia,[25] Maryland,[8,29] Delaware [14,21] and New Jersey.[26]

Habitat and movements: Adults—oyster reefs,[22,30] around rocks,[22,27,28,31] aquatic vegetation [6,20,27,28,31] or around sunken debris,[12] most common where bottom sandy or muddy; [28] found mostly in lower and middle region of estuary; [30] migrate into deeper water to overwinter [4,6,29] but may be found as shallow as 3 m in winter; [4] also move into deeper, cooler water when water temperature goes above 30 C; females move into *Zostera* or *Ruppia* beds, where available, after spawning; tagged individuals have exhibited movement up to 9 km; [36] found in salinities from 0 [11]–34.2 ppt; [32] reported to stop feeding at 4.4 C [6] and taken from temperatures up to 32 C; [35] typically nearshore [31] in shoal waters.[28]

Larvae—yolk-sac larvae remain attached to substrate of nest site until yolk absorbed, cared for by male parent; [2,19] found in upper estuary of Mystic River; [17] in coves or along grassy shores in June or July.[31]

Juveniles—among debris over mud or silt bottoms,[21] *on* oyster beds in winter; [31] found in salinities of 13–29 ppt and temperatures of 15–23 C; [21] collected only in bottom tows.[17]

SPAWNING

Location: In cavities among shells or rocks, often in tin cans, broken bottles or other artificial sites near human habitats.[2,34]

Season: In Chesapeake Bay region April to July [2] or August,[18] around Woods Hole, Massachusetts, May [5] or June to July; [3,28] season may be split into two parts.[6]

Temperature: About 17.5–27 C or higher,[4] 17 C thought to be about the minimum.[5]

Fecundity: Usually fewer than 200 eggs in a clutch,[13,37] no other information.

EGGS

Location: Middle and lower estuary [18] in nests, deposited on underside of some projecting object,[1] guarded by male,[2,4] rarely by female.[5] Usually attached in aggregates of a single layer [15,34] but occasionally there are 2 layers.[34]

Fertilized egg: Spherical but flattened at side of attachment; [34] micropyle more or less opposite attachment site; [19,34] diameter about 5 mm [2,3,8,13,15,17,28] to 5.5; [15] golden [10] or dirty yellow; [15] adheres to natural or artificial substrates,[2] attached by a discoidal area about 3 mm diameter; [13,15,34] yolk homogeneous; no oil droplets [13,15] or several (yellowish) in region of micropyle.[34]

EGG DEVELOPMENT

Blastodisc develops at lower pole (away from attachment site).[13,15] At about 27 C blastodisc distinct after 3 hours;

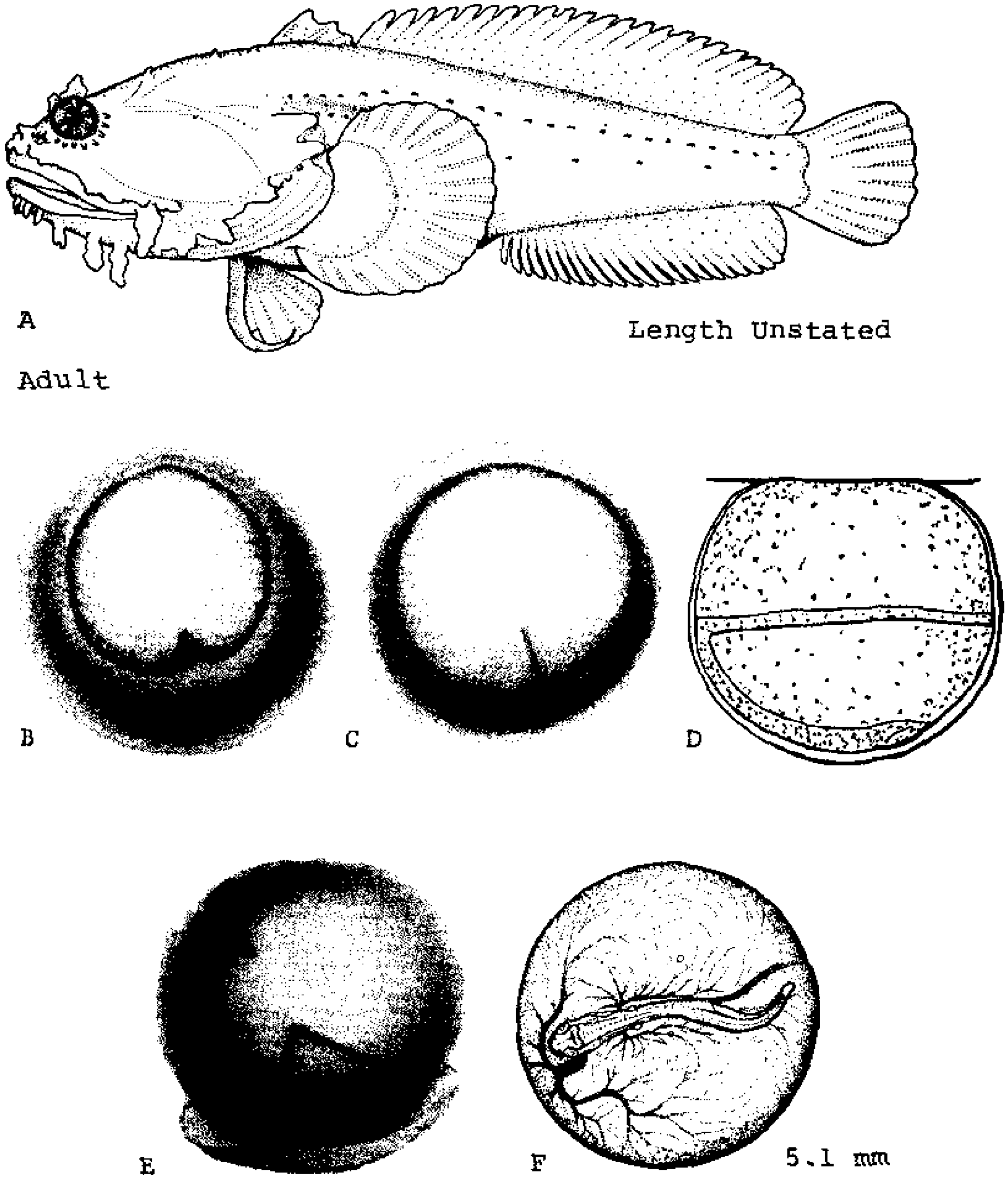


Fig. 178. *Opsanus tau*, Oyster toadfish. A. Adult, length unstated. B. Egg, ca. 4.6 mm, ventral view in relation to deposition, blastoderm covering about 1/5 of yolk surface, posterior notch formed. C. Egg, ca. 4.6 mm, blastoderm covering about 1/4 of yolk surface. D. Egg, diameter unstated, lateral view, blastoderm covering about 1/2 of yolk surface. E. Egg, ca. 4.9 mm, near closure of blastopore, germ ring notch obvious, adhesive disc shown. F. Egg, diameter 5.3 mm, embryo 5.1 mm. (*A, Bigelow, H. B., and W. C. Schroeder, 1953: fig. 274. B, C, E, Wallace, L. B., 1899: plate II. D, Ryder, J. A., 1886: fig. 4. F, Dovel, W., 1960: fig. 1.*)

at about 5 hours two-cell stage reached and at about 6 hours four-cell stage reached.[34] All other information lacking temperature data. Blastodisc never high; embryonic axis established at 48–60 hours [34] or on 4th or 5th day.[16]

Tracy series: [5]

1st stage, fertilization to formation of 1st somite—duration 5–6 days, neurulation occurs late in this stage.

2nd stage, 1 somite to 11 somites—duration 2 or 3 days, age 7 or 8 days at end of stage; at 4 somites optic vesicle formed and expanding posteriorly; at 6 somites optic stalk differentiated; brain differentiating into major portions; 6–8 somites, otic vesicle recognizable; 11 or 12 somites olfactory placode visible.

3rd stage, 12 somites to 17 somites; or beginning of heart beat to earliest somite contraction—duration 2 to 3 days, age 8–9 days at end of stage, length 2.76 mm at end of stage; lens vesicle begins invagination; brain major divisions well differentiated; vascular system develops.

4th stage, 18 somites to 30 somites or period of development of contractability of the somites of the trunk—duration 2 days, age 9–11 days at end of stage, length 4 mm at end of stage; earliest contraction of embryo at 17–19 somites; tail free; incurrent nare beginning formation; pectoral fin bud next to anterior 4 or 5 somites.

5th stage, 31 somites to beginning of respiratory movement—duration 6 days, age 17 days at end of stage, 6 mm at end of stage; body able to make coordinated "C" or "S" coils; swim bladder begins as a diverticulum; pelvic bud appears as a thick ridge behind pectoral fin.

6th stage, respiratory movement to hatching—head becomes separated from yolk; head and anterior part of body lengthen, fins and opercular opening become separated; pectoral fin becomes closely related to branchial apparatus; pelvic fin reaches gular position anterior to pectoral fin.[5]

Incidental observations during embryogenesis are that the embryonic ring has a notch at a distance posterior to the forming embryo, this notch being present almost to blastopore closure; [6,34] yolk circulation is established prior to blastopore closure and tail remains attached to yolk sac prior to blastopore closure.[6]

Incubation period: 5–12 days at an unstated temperature [4] to 3 weeks at about 20 C.[3]

YOLK-SAC LARVAE

Hatch at 6 mm,[3] 7 mm [5] or 7.4 mm. Yolk absorbed at about 480 hours after hatching [12] at a length of 16 to 18 mm TL.[2] End of stage arbitrarily defined as time of release from substrate which occurs near the time of yolk absorption (FDM).

D. III–25 (adult complement) at 10.88 mm TL, III–26 at 12.62 mm TL; A. 21 (adult complement) at 10.88 mm TL, 22 at 12.62 mm TL; C. 14 (adult complement of primary rays) at 10.88 mm TL, 15 at 13.20 mm TL, 16 at 16.28 mm TL, probably 18 (adult complement of primaries plus procurrents) at 18 mm TL; myomeres 12 (countable) + 31 + (countable); vertebrae not countable, not visible anterior to pectoral fin.[2]

Head length 25.1–33.1% TL, increasing with length; eye length 7.6–9.0% TL; greatest depth 112.5–21.7% TL decreasing with length; snout to vent length 44.9–52.3% TL, decreasing with length.[2]

Body form similar to adults well before yolk absorption complete; [13] cirri under mouth forming at 13.7 mm TL. Yolk mass shifts forward and upward at 12.4 mm TL;[2] becomes constricted during absorption.[2,13,34] Mouth rudimentary at hatching, developed at 8.2 mm TL (24 hours after hatching),[2] or opens within 2–3 days after hatching; [3] Meckel's cartilage and pterygoquadrate discernible at hatching.[5] Eye transparent at hatching,[2] with choroid fissure visible, begins movement at 9.5 mm,[3] characteristic St. Andrew's cross color pattern in iris at 13.7 mm (168 hours after hatching). Lateral line well developed by 13 mm TL.[15,19]

All median fins developing well by 10.8 mm TL (72 hours after hatching), complete by 13.7 mm TL (168 hours after hatching); paired fins present as buds at hatching, rays developing at 10.8 mm TL,[2] pelvic begins behind pectoral later moving anterior to it.[2,13,15]

Heart moves dorsad from surface of yolk to a position near body at 8.2 mm TL (24 hours after hatching), changes from vertical to more or less horizontal at 9.1 mm TL (48 hours after hatching), behind branchiostegal rays and no longer visible at 10.8 mm TL (72 hours after hatching).[2] Gas bladder heart-shaped, partially divided into anterior and posterior chambers at 17.5 mm TL.[2]

Pigmentation: At hatching usually transparent[2] only a few very small punctate spots and in the iris.[2] At 24 hours after hatching (8.2 mm) body opaque, a thin scattering of melanophores. At 96 hours after hatching (12.4 mm TL) dispersed accumulation of melanophores beginning to form a pattern.[2] Pattern first appears as 3 faint bands of grayish color, one at caudal base, two across median portion of tail, later 4th band appears in region of spinous dorsal and the two bands on the tail extend onto dorsal and anal fins.[34] Older specimens with a quantity of light orange pigment giving a general color of light buff mottled and crossed with black bands.[3]

Iris coloration distinct. At 9.5 mm TL black underneath covered with a bluish gray filmy material, inner edge black with faint copper tint; black pigment concentrated in certain regions so that there are 2 darker regions in posterior half and one large dark area in anterior half. At 17 mm TL 4 pigment bands arranged in a St. Andrew's

A

7.4 mm TL

B

ca. 5.6 mm TL

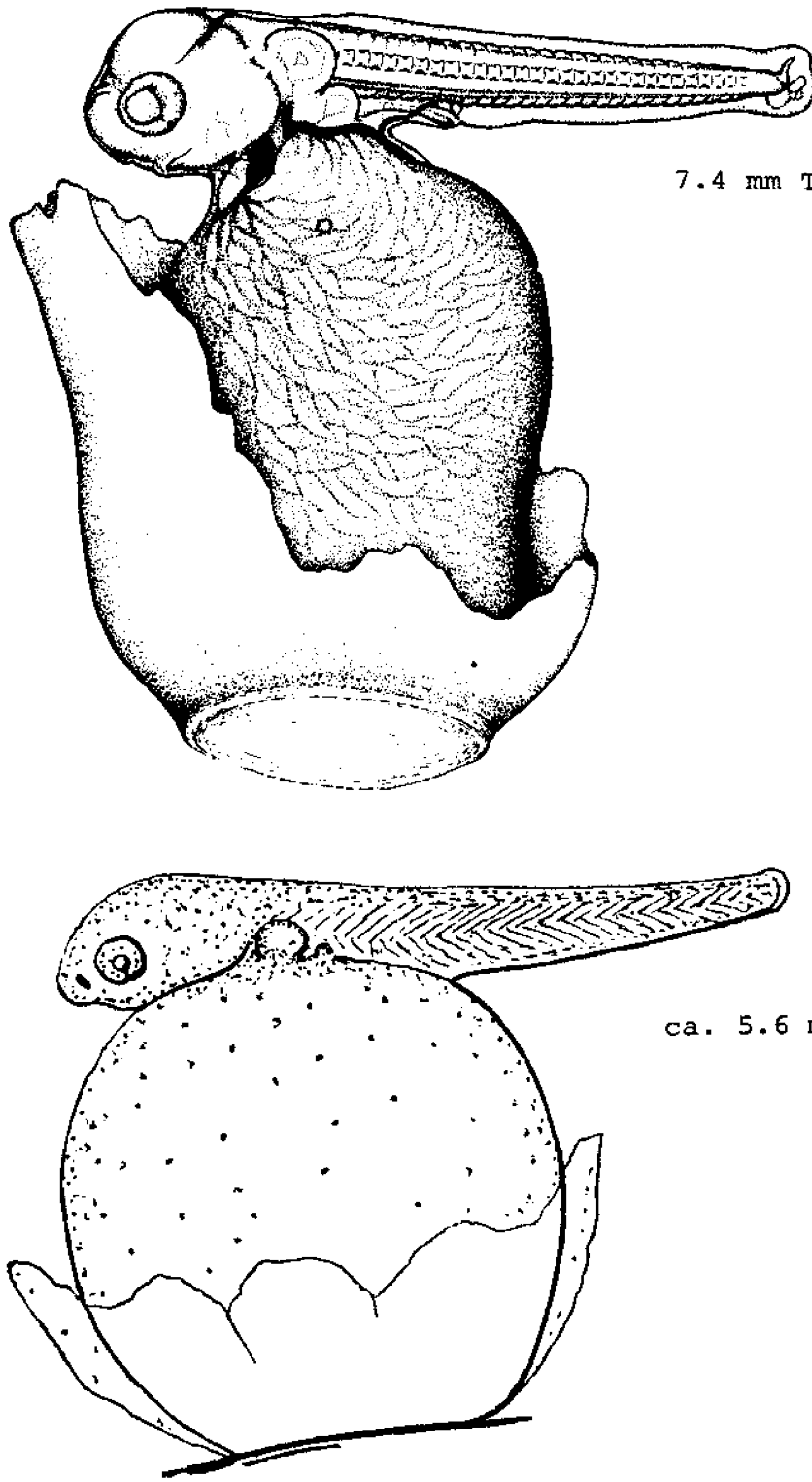
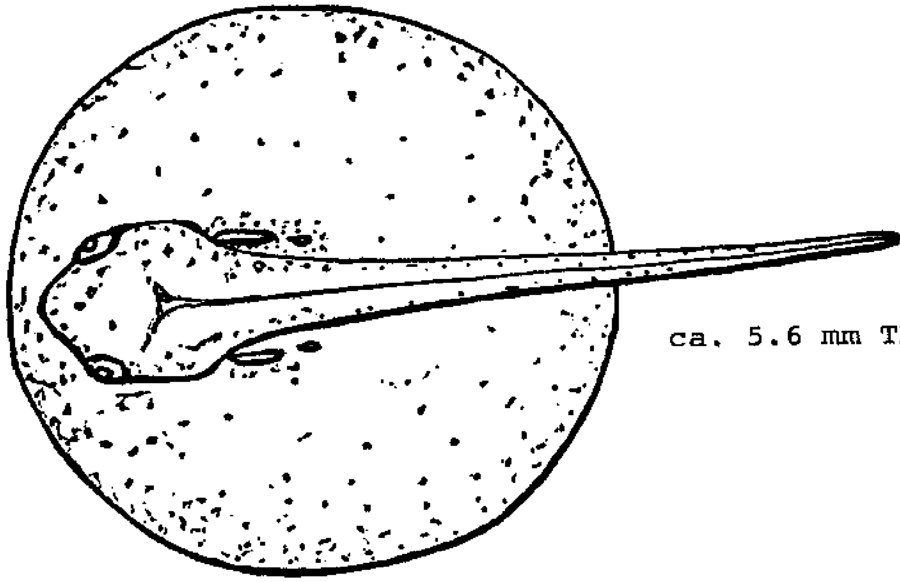


Fig. 179. *Opsanus tau,* Oyster toadfish. A. Yolk-sac larva, 7.4 mm TL, about 24 hours after hatching. B. Yolk-sac larva, ca. 5.6 mm TL. This length may be in error, estimated from illustration. Yolk-sac shape questionable. (A, *Dovel, W., 1960: fig. 2. B, Ryder, J. A., 1886: fig. 2.*)

A



B

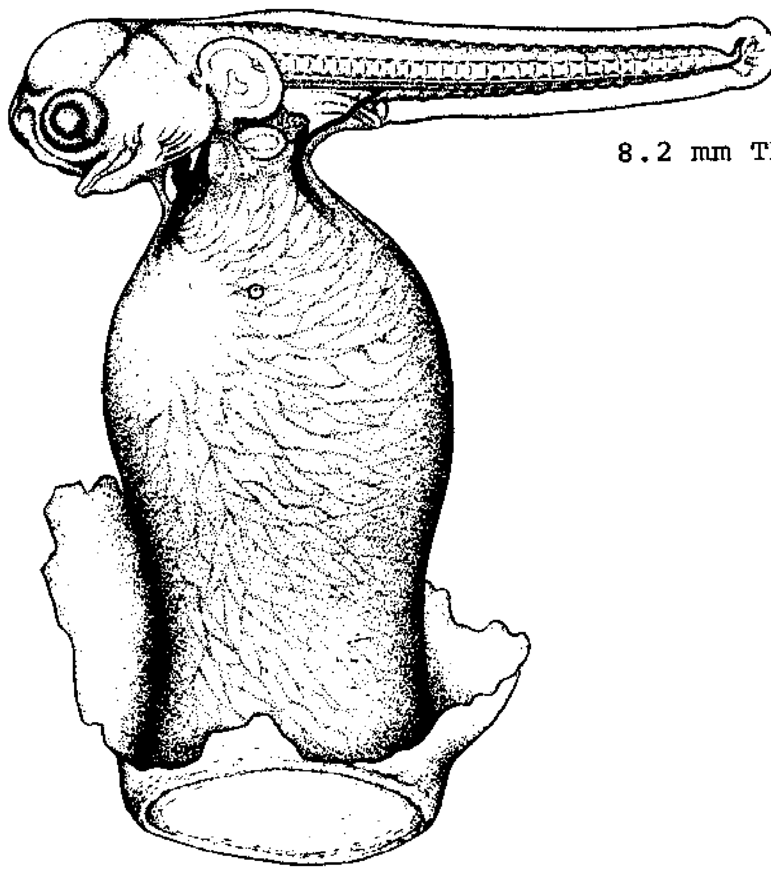


Fig. 180. *Opsanus tau*, Oyster toadfish. A. Yolk-sac larva, 5.6 mm TL, see Fig. 179 for lateral view. B. Yolk-sac larva, 8.2 mm TL, about 48 hours after hatching. (*A, Ryder, J. A., 1886: fig. 3. B, Dovel, W., 1960: fig. 3.*)

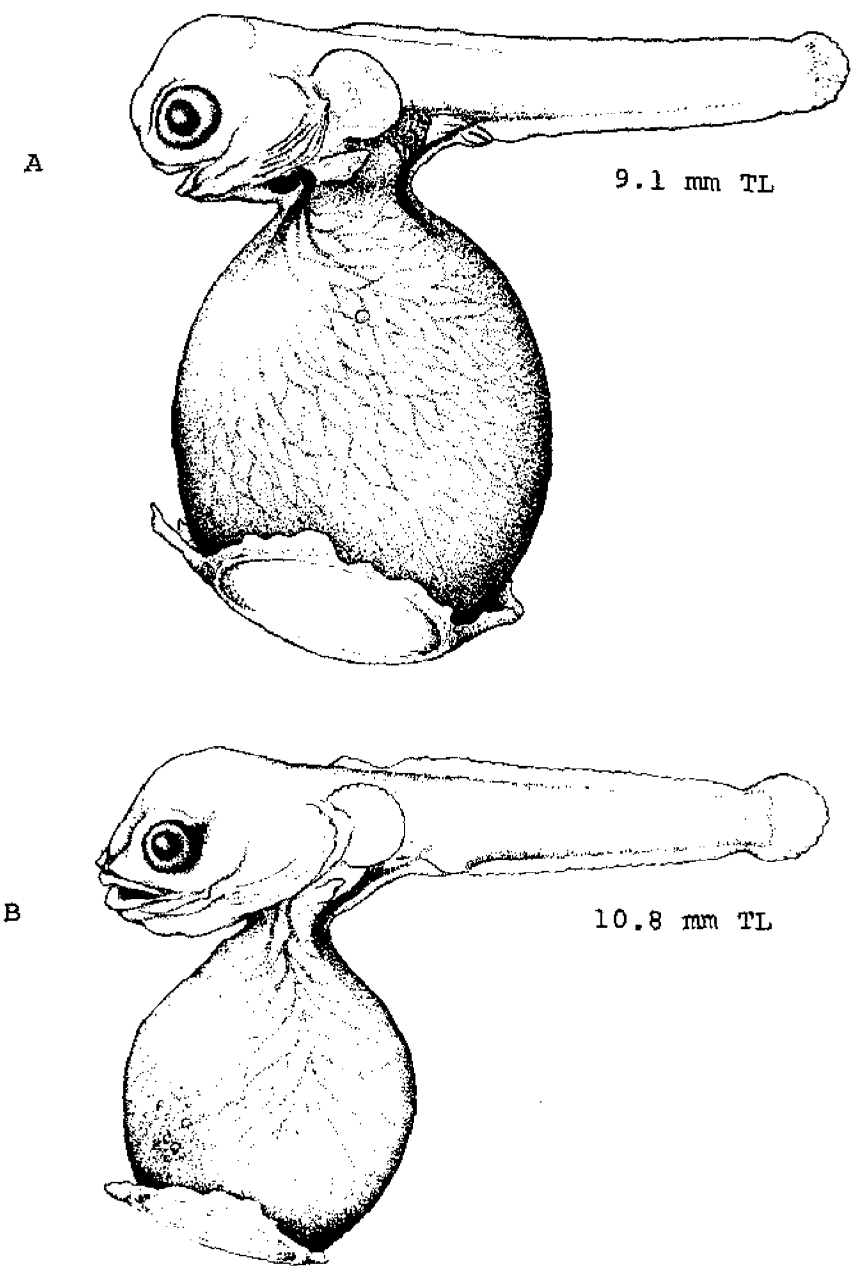
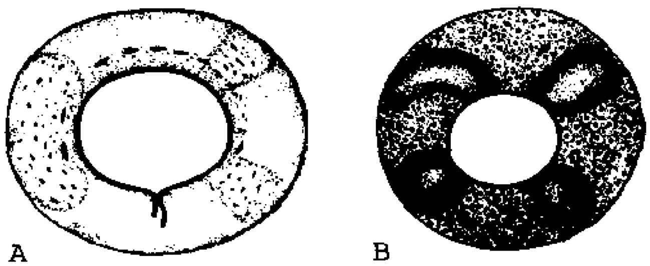


Fig. 181. *Opsanus tau*, Oyster toadfish. A. Yolk-sac larva, 9.1 mm TL, about 92 hours after hatching. B. Yolk-sac larva, 10.8 mm TL, about 7 days after hatching. (*A, B, Dovel, W., 1960: figs. 4, 5.*)



A B

Fig. 182. *Opsanus tau*, Oyster toadfish. A. Iris of yolk-sac larva 9.5 mm TL, showing pigmentation and choroid notch. B. Iris of yolk-sac larva 17 mm TL showing distinctive pigmentation. (*A, B, Tracy, H. C., 1926: plate I.*)

cross, each black band with a lighter area in middle due to lack of pigment; area between bands appear like a thick-meshed blue veil with underlying black showing through; light orange pigment spots scattered over superficial tissue of eye.[3]

LARVAE

Juvenile stage obtained by time of yolk absorption and release from substrate, therefore no larvae definable for this species.

JUVENILES

Become free-swimming between 16 and 18 mm TL, adult fin ray complement by 18 mm TL.[2]

Body form essentially that of a small adult by time of yolk absorption.[34]

Pigmentation: Smaller specimens with light orange pigment giving a general color of light buff mottled and crossed with black bands. Larger specimens from grass beds with a decided greenish tinge.[3]

GROWTH

Males grow faster than females during the first year; from the 2nd to the 6th years females display greater annual growth increments, males during this period less than 20 mm TL/year, females more than 20 mm TL/year.[7]

AGE AND SIZE AT MATURITY

Mature at 3–4 years.[31] Smallest female with discernable egg development 106 mm TL,[35] smallest ripe female 140 mm TL;[34] males showing spermatogenesis by 146 mm TL[35] or 152 mm TL.[34]

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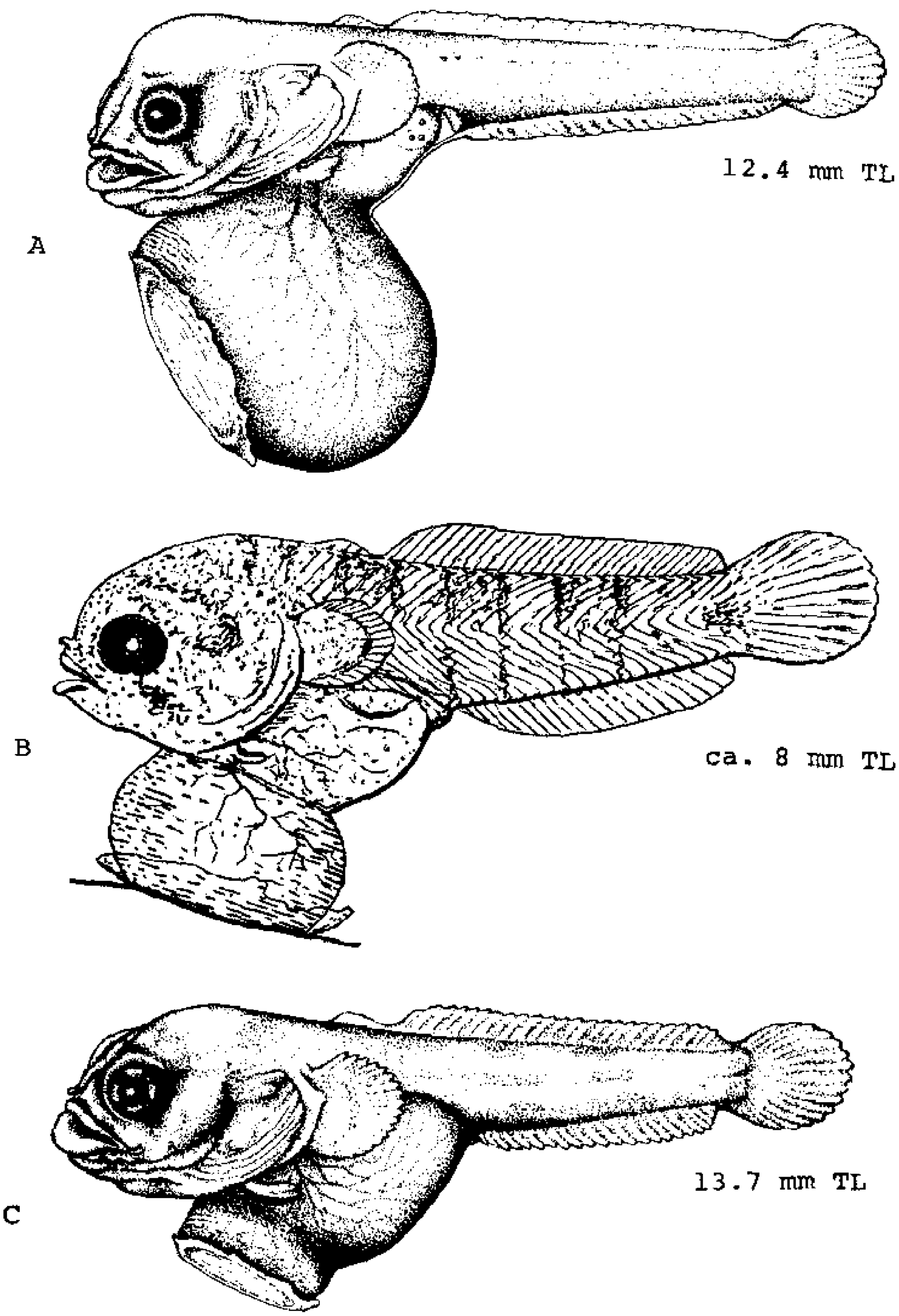

Fig. 183. *Opsanus tau,* Oyster toadfish. A. Yolk-sac larva, 12.4 mm TL, about 8 days after hatching, yolk sac shifted forward. B. Yolk-sac larva, ca. 8 mm TL, length estimated from illustration, may be in error, yolk sac constricted. C. Yolk-sac larva, 13.7 mm TL, about 11 days after hatching. (*A, C, Dovel, W., 1960: figs. 6, 7. B, Ryder, J. A., 1886: fig. 1.*)

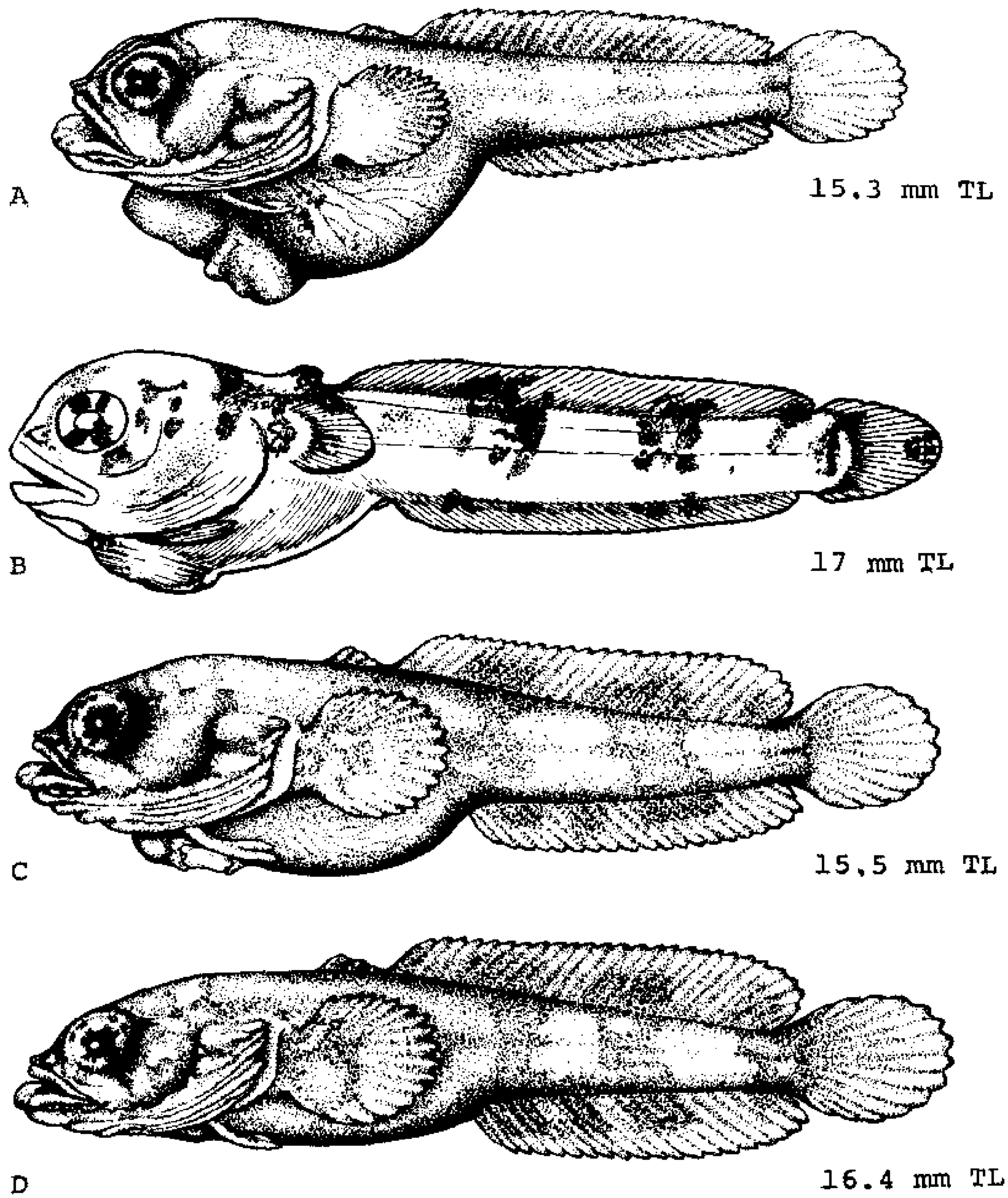

Fig. 184. *Opsanus tau*, Oyster toadfish. A. Yolk-sac larva, 15.3 mm TL, about 12 1/4 days after hatching. B. Yolk-sac larva, 17 mm TL. C. Yolk-sac larva, 15.5 mm TL, about 14 3/4 days after hatching. D. Yolk-sac larva, 16.4 mm TL, about 16 2/3 days after hatching. (*A, C, D, Dovel, W., 1960: figs. 8, 9, 10. B, Tracy, H. C., 1926: plate* 2.)

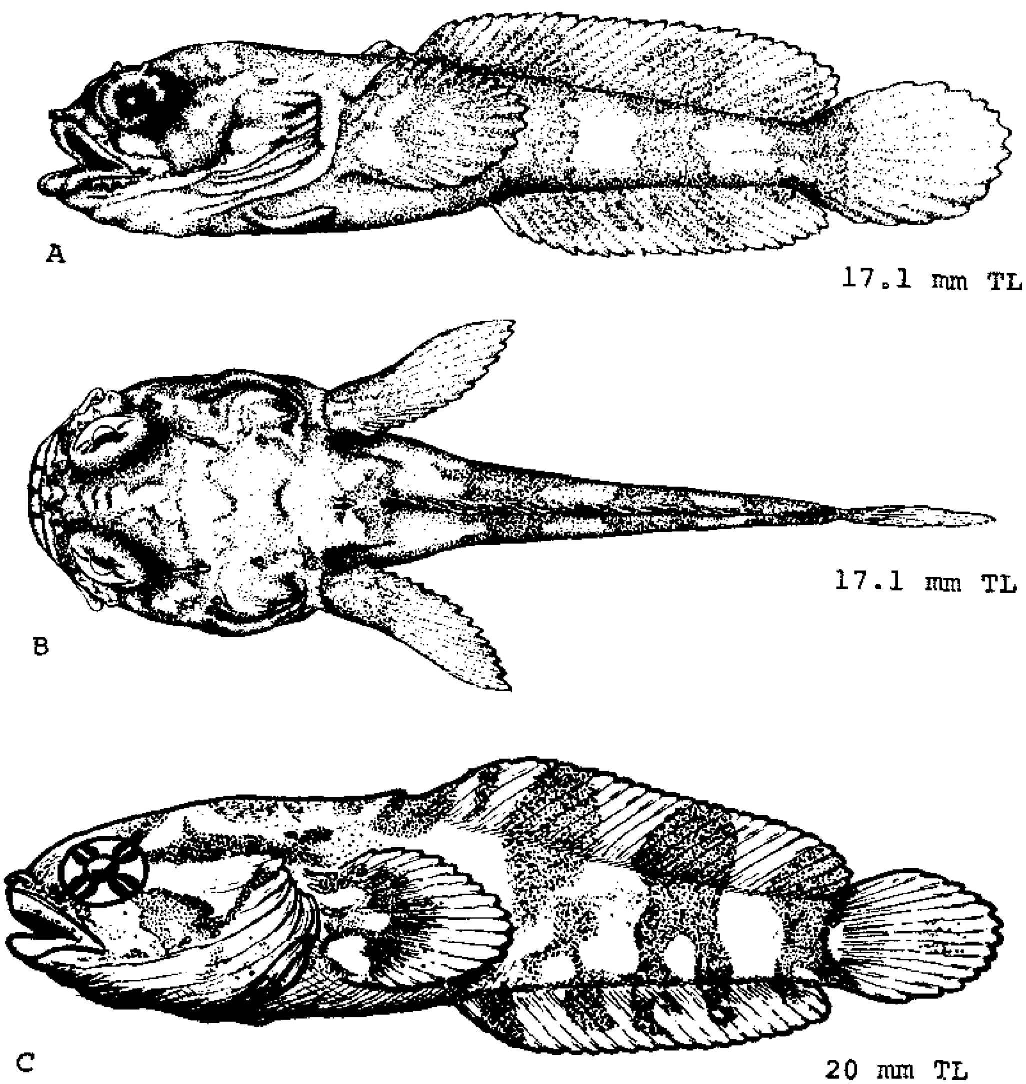

Fig. 185. ***Opsanus tau***, Oyster toadfish. A. Yolk-sac larva, 17.1 mm TL, about 20 days after hatching. B. Yolk-sac larva, dorsal view of A. C. Juvenile, 20 mm TL. *(A, B, Dovel, W., 1960: figs. 11, 12. C, Tracy, H. C., 1926: plate 2.)*

Porichthys plectrodon Jordan and Gilbert, Atlantic midshipman

ADULTS

D. II, 33–39, mode II, 36; [2] A. 31–37, mode 33; [1,2] C. 13 principal rays (6 dorsal, 7 ventral), total elements 15; [2] P. 15–19, modes 17, 18; [1,2] V. I, 2; vertebrae 41–47, mode 44; gill rakers 10–17, mode 13; branchiostegals 6; no scales.[2]

Proportions as percent of head length: Head width 66; head depth 44; maxillary 57; pectoral fin length 63; pelvic fin length 37; soft dorsal height 33; anal fin height 30.[6] As percent of SL: Head length 26–31; pre-first dorsal length 25–30; pre-second dorsal length 31–37; first dorsal origin to caudal base 63–76; prepelvic length 15–22; preanal length 38–47; orbital diameter 4–7.[2]

Body elongate, tapering, compressed posteriorly; head depressed, frontal region forming a triangular area below level of temporal region, its median ridges very low; suboperculum poorly developed and spineless; operculum with a grooved poison spine; gill opening extending obliquely downward from upper pectoral edge to below and just behind pelvic fin insertion; no frenum; lower jaw projecting; maxillary extending beyond eye; premaxillary non-protractile.[2] Teeth in a single series on jaws, vomer and palatines; [6] premaxillary teeth directed forward in most adult males; [1,2,6] and in about 5% of females; [1] lower jaw teeth hooked backward and inward; palatine teeth 4 or 5, strong,[6] confined to front part of bone,[3] and directed forward in both sexes.[3,6] Soft dorsal fin long and low, from midway above pectoral base to caudal base, not adnate to caudal; anal fin long and low, without spines, not adnate to caudal; pectoral fin broad, pointed bluntly, extending back to dorsal ray 6–8. Four lateral lines (with cirri) on head and body; [2] pleural lateral line continued to end of anal fin.[3] Photophores (termed pores in older records) present in rows; ca. 25 (21–30) on mandibles, 40 (34–47) on branchiostegals, 40 (32–49) on gular region, 35 (30–41) on gastric region, 38–41 (31–46) in ventral region, and 36 (30–40) in anal region; branchiostegal photophore series having a forward-directed, U-shaped commissure at its apex.[2]

Pigmentation: Small to medium sized brown to black spots on dorsal fin and upper part of head and body, the spots showing considerable geographic variation with regard to number and distinctness; background color of body varying from very pale to very dark; belly often golden in life. Pectoral fins with faint dark spots, the lower rays slightly grayish; anal fin edged with black; upper two-thirds of dorsal fin with spots, usually in two horizontal rows running length of fin; fin spots somewhat variable in shape, number and distribution, but those in lower row generally longer and more oblong in shape (about twice as long as those in upper row), their horizontal length equal to distance between fin rays; in some cases the fin spots are not at all confluent, whereas in extreme cases those in lower row are joined in such a way as to form a line of pigment running length of fin; spots on upper part of body encroaching slightly on lower part of dorsal fin in nine to eleven places; caudal fin dark near base, bordered by a wide, pale area, and becoming progressively darker toward tip; dark pigment distributed over most of lower jaw, in no particular pattern; underside of body and head either dusky or not, depending on environmental conditions.[2]

Maximum length: 218 mm SL in U.S. waters, 315 mm SL in South American waters.[2]

DISTRIBUTION AND ECOLOGY

Range: Atlantic continental waters from Cape Henry, Virginia [2] to central Brazil.[9]

Area distribution: Cape Henry, Virginia.[2]

Habitat and movements: Adults—bottom dwellers, burrowing in the substrate during daylight and normally emerging at night to feed, not emerging during cold weather. Largest populations over mud bottoms, but present in lower density over sand, choosing mud in

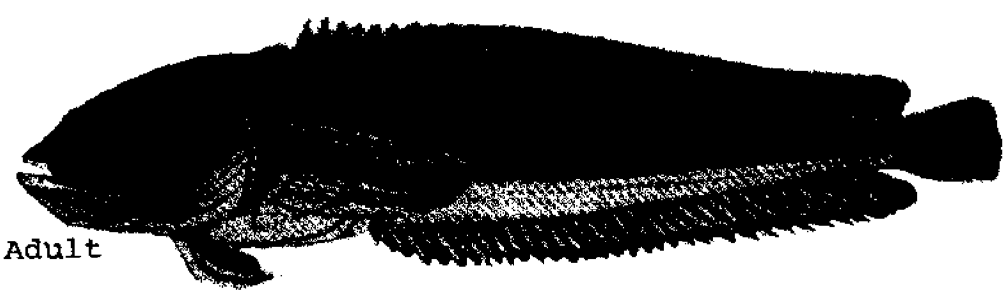

Fig. 186. *Porichthys plectrodon,* Atlantic midshipman. A. Adult, length unstated. (*A, Lane, E. D., 1967:* Frontispiece.)

preference to sand substrate in laboratory tests.[1] Occurring at salinities above 10 ppt.[8] Not taken in surf zone, most common at moderate depths (3–55 m),[1,7] rare below 55 m in Texas,[1] but reported from 256 m in Caribbean.[2] Most common in ship channels in Texas bays, entering, from the Gulf, as ripening adults mainly in the spring, but with a few overwintering in the bays, and a small group entering from May through August. Almost all females and many males believed to die after first spawning, some males thought to winter in the Gulf and return a second year.[1]

Larvae—not studied in this species. Yolk-sac larvae possibly attached to underside of stones or shells as reported for Pacific members of the genus.[5,10]

Juveniles—depth and substrate preferences not indicated to differ from adults, possibly favoring shallower depths (GED), bay hatched young enter the Gulf of Mexico between early May and late October, with the peak migration in June and July. Some young winter in the bays. Gulf-spawned young remain for the most part all year, but a few enter the bays in the fall and leave during the next summer.[1]

SPAWNING

Location: In Texas, bay-spawning and Gulf-spawning populations partly separable by meristics and spawning season, but evidence of some exchange of individuals between populations. Sunken oyster reefs cited as likely bay spawning areas but evidence inconclusive. Gulf adults collected during spawning season at water depths of 13.7, 21.9, 27.4 and 45.7 m; ripe and recently spent individuals more than 80% of sample at 27.9 m and less than 5% at any other depth.[1]

Season: Only established for Texas, where major spawning peak in bays April–May, a minor peak August–early September, in Gulf one peak in late September–October, little spawning activity at times other than peaks.[1,7]

Spawning time: Unknown. Possibly at night involving bioluminescent photophore displays and courtship sounds (GED, see Crane, 1965 on *P. notatus*[4]).

Spawning temperature: Spring spawning peak in Texas bays when water temperatures approach 25 C, fall Gulf spawning peak when waters there approach 25 C, late summer peak in bays (of minor importance) at 29–30 C.[1]

Fecundity: Ovarian egg count in 92–139 mm SL females ranged from ca. 85 to ca. 310, mean count 140.5 in sample of 67 adult females. Logarithm (base 10) of egg count ca. 1.0647 plus 0.00968 times SL in mm, with a correlation coefficient (r) of 0.836 for the regression.[1]

EGGS

Description: Average diameter of ripe ovarian eggs 3.5[1]–3.8 mm,[10] range to 4.0 mm or "up to 5 mm."[3]

EGG DEVELOPMENT

No information.

YOLK-SAC LARVAE

No information.

LARVAE

Because fin rays are complete before yolk absorption, the larval stage, as defined in this series, is not present.[5]

JUVENILES

Similar to adults in morphology and pigmentation.[1]

GROWTH

Growth essentially linear from 37 mm SL (typical size in June) to 110 mm SL (typical size in February), given by equation SL = 21.038 plus 7.767 times the age in months.[1]

AGE AND SIZE AT MATURITY

Females 92–139 mm SL, mean 110 mm SL; males 80–186 mm SL (larger range probably includes 2 year olds); age one year in both sexes.[1]

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Lophius americanus

goosefishes
Lophiidae

FAMILY LOPHIIDAE

This family, the angler fishes, has recently been listed to contain 22 species divided among four genera (Caruso, 1975). Distribution was described by le Danois (1974); it is generally world-wide and includes a wide range of water depths, with some tendency to favor greater depths in the warmer latitudes (Goode and Bean, 1895).

Lophiids are pediculate fishes, an order whose members have arm-like paired fins supported by elongate actinosts which actually function in locomotion on the ocean floor. The family is distinguished from other pediculates by a large, wide, depressed head; exceedingly large mouth with a projecting lower jaw; tapering body; smooth, soft skin; no gill rakers; a comparatively large gill opening behind and somewhat below the axil of the pectoral fins; and three dorsal spines on the head with three smaller ones behind the head (Goode and Bean, 1895; Regan, 1912; Jordan and Evermann, 1896–1900).

Larvae of the American species of *Lophius, L. americanus* Valenciennes, are more easily distinguished from those of the European L. *piscatorius* Linnaeus than are the adults, using characteristic differences in pigmentation (Tåning, 1923). Tåning, after studying early developmental stages, considered the two species as distinct at a time when many authors regarded them as synonymous. Tåning also pointed out similarities between *L. americanus* and *L. budegassa* of the Mediterranean, whose development has been described by Padoa (1956) and earlier workers. A popular account of the American angler by Gill (1905) contains interesting natural history information, including a credit to the Greek philosopher Aristotle for brief mention of the egg raft of *Lophius*.

Lophius americanus Valenciennes, Goosefish

ADULTS

D. VI–11–12 (JHC); A. 9–10; [2,18] P. 25–28 ($\bar{x}=26.1$) (JHC); V. I, 5; [36] C. 8; vertebrae 28; [2] no scales,[10] or gill rakers; [4] gill arches 4, gills on first 3 only (JHC); branchiostegals 6; [2] jaw teeth in 1–3 [10] or 4 [22] rows; humeral spines with 3 unequal points; preorbital mucous pores in supraorbital canal 12–15; jugo-malar line zig-zagged slightly from near palatine spines to branchiostegal line.[33]

Proportions as percent SL: Head length 31.3–35.6; 1st D. spine length 19.5–25.9; 2nd D. spine length 13.5–27.7; 3rd D. spine 3.2–9.7. Proportions as percent HL: head width 49.0–57.7; head depth 66.5–74.5; snout width 23.7–27.5; snout length 52.5–59.4 (JHC). Eye ca. 10 in head,[18] ca. 5 in interorbital space.[22] Conventional measurements unsatisfactory because of mobile suspensorium, lack of bony orbits, etc.[34]

Head and body much depressed; head wider than trunk; trunk tapering rapidly, giving a tadpole-like appearance. Mouth very wide, lower jaw projecting far beyond upper so lower teeth exposed, even with mouth closed.[10] Jaw teeth large, conic, uneven in length, backwardly directed and very sharp.[10,22] Strong teeth on vomer and palatines; [18] 3 patches of upper pharyngeal teeth (JHC). No gill covers, membrane united across isthmus, gill openings behind pectorals in lower axil of fin.[4] Olfactory organs flattened, stalked bulbs lateral to illicial pterygiophore, somewhat larger in males than in females.[35] Pectorals rounded, their bases constricted and arm-like, supported by 2 radials; pectoral membrane strong and covered with heavy skin; posterior rays strengthened and turned under, forming a scoop. Pelvics also with heavy skin; articulated for mobility in all directions; located on lower surface of head, well ahead of pectorals; first pelvic ray closely joined with second, giving external appearance of 5 rather than 6 rays.[25] First dorsal spine (illicial bone) with expanded tip (esca) forming a lure for prey, depressible, directly overhanging mouth when erected [4] reaching past base of third spine when depressed; [22] second spine usually slightly longer than first, also depressible, with projecting fringes that obscure its outline; located ahead of eyes; third spine shorter, behind eyes, its base embedded in the flesh; second and third spines with small triangular membranes at bases; spines IV–VI still shorter, delicate, connected by membrane. Soft dorsal with highest rays in middle, roughly triangular. Anal fin similar to soft dorsal, opposing it but very slightly behind it.[7,18] Caudal margin straight, fin broom-shaped.[10] Flesh and skin soft, skin smooth and secreting copius tough tenacious mucus if animal is handled; [24] muco-lateralis system extensive but obscure.[35] Branched, fleshy fringes present along margin of mandible and head back to pectorals, scattered on pectorals, and continuing in a double row back along flanks to caudal peduncle.[3,7,18]

Pigmentation: Color variegated above, principally light and dark brown; underparts white to dusky; [4] pectoral, dorsal and caudal fins colored like body, but with edges dark; [18] anal tinted with brownish; [22] pelvics reddish.

Maximum size: Usually stated as 1200 mm TL, weight 23–27 kg.[10,18]

DISTRIBUTION AND ECOLOGY

Range: Western Atlantic along the eastern coast of North America from the northern Gulf of St. Lawrence to Cape Hatteras; [10,17,18] less common to about Cape Canaveral in Florida (JHC). Similar, but distinct (JHC) form(s) in deep tropical waters off Barbados, on the Yucatan Banks [18] and off Cape Frio, Brazil.[32,33] Long considered identical to *L. piscatorius* of the eastern Atlantic, which ranges from the Faroes and Norway to Cape Blanc in west Africa,[18,33] but suggested to be closer to *L. budegassa* of the Mediterranean and *L. vaillanti* of the Azores and west Africa.[2,33]

Area distribution: Fairly common on the continental shelf throughout the Mid-Atlantic Bight.[2,4,20,22] Fall, winter and early spring records in lower Delaware, Isle of Wight and Chesapeake Bays.[4,9,19]

Habitat and movements: Adults—sluggish, bottom-associated fishes occupying a great range of depths down to 668 m.[17,18,23,31] Individuals present in shallow water in spring and fall, apparently retiring to deeper water in both very warm and very cold weather; [23] taken in trawls from deeper parts of the bays in winter,[19] but concentrated between 180 and 255 m; [31] some evidence that south of Cape Cod it retreats to deeper water offshore in summer.[3,18] Canadian temperature range 0–10 C in winter, concentrated at 3–6 C, 0–12 C in summer, concentrated at 5–9 C.[31] Reported sometimes to bask near the surface [5] and to capture waterfowl at the surface.[3,24]

Yolk-sac larvae—found in a mucous veil from surface to depths of 15 m.[2] In aquaria float yolk uppermost after emerging until about 5 days post-hatching.[1,20]

Larvae—found from surface down to 25 m in Labrador Current.[2] Sixth day post-hatching, in aquaria, swam head downwards concentrating about 8 cm below the surface, next day moving downwards but beginning to die.[1]

Prejuveniles—scattered evidence that a specialized, somewhat laterally compressed pelagic stage lasts to 55–65 mm TL.[11,28] A 52 mm TL specimen reported from a floating mat of *Fucus* swam with head at surface, body inclined downward at a slight angle.[11]

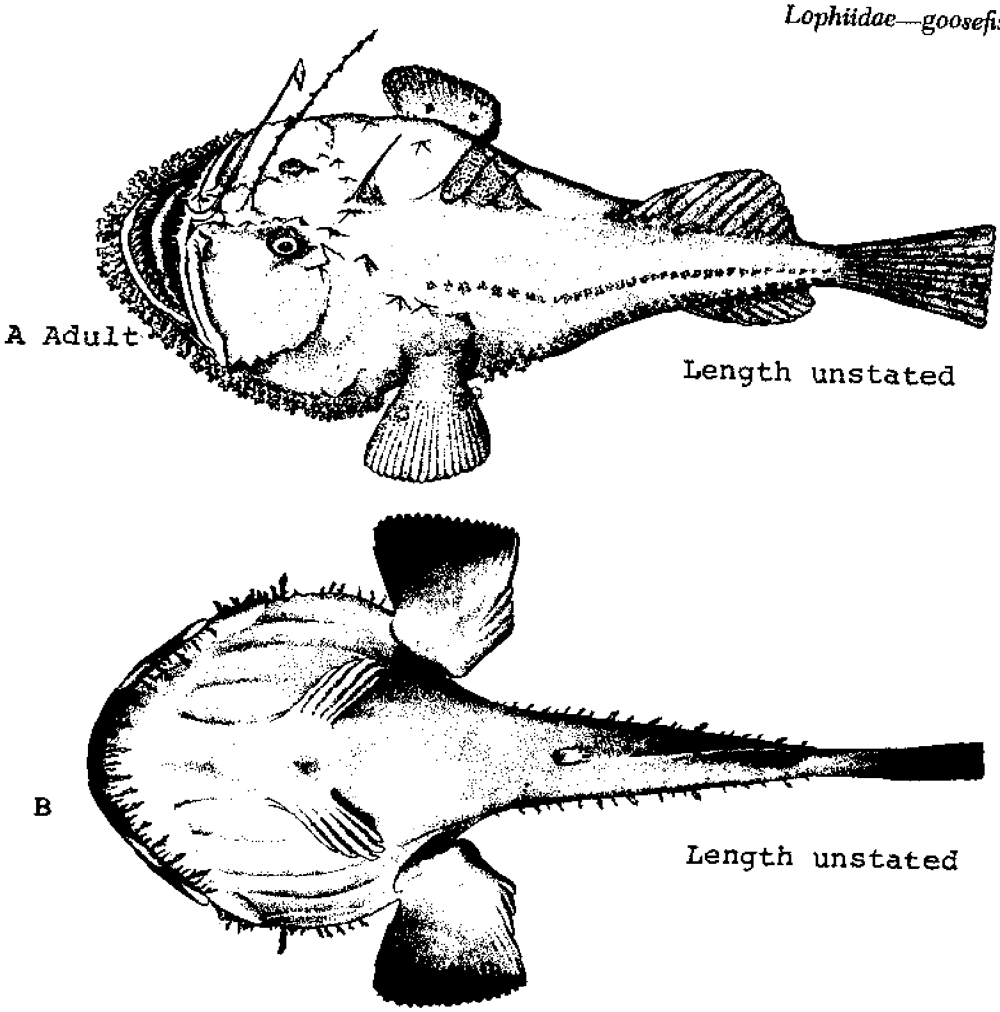


Fig. 187. Lophius americanus, Goosefish. A. Adult, dorsolateral view. B. Adult, ventral view. (*A, Leim, A. H., and W. B. Scott, 1966: 421. B, Goode, G. B., and T. H. Bean, 1896: pl. 118, fig. 400b.*)

Juveniles—larger than ca. 65 mm TL taken in bottom trawls, but rarely.[10,28] Habitat and movements poorly known (GED).

SPAWNING

Location: No eyewitness accounts of spawning in literature. Eggs with *young* embryos taken from inshore to edge of continental shelf.[1,9,10,16]

Spawning season: June to September in Canadian waters,[18] reported April to June or July in Mid-Atlantic Bight,[9,10,15,21] to September in Maine,[10] and probably until at least October from Delaware to Long Island (GED-based on probable age of larvae collected by NMFS at station C-7 [30]).

Time: Suggested to be early morning [1] (from stage of eggs taken in afternoon, GED).

Temperature: At actual spawning site unknown. Young eggs at 8–14 C.[1,26]

Fecundity: Ca. 1,300,000 eggs in collected egg mass,[14] ca. 543,000 ovarian eggs in 660 mm specimen.[25]

EGGS

Location: Eggs embedded in a continuous, ribbon-like sheet of gelatinous mucus 0.15–1.5 m wide and 6–12 m long. *One or two, sometimes three eggs each in roughly* hexagonal, liquid-filled chambers arranged in a single irregular layer within the mucus.[1,13,14] Diameter of chambers approximately twice egg diameter.[23] Mucous sheets, termed "veils," somewhat lighter than seawater,[24,28] often found floating but reported from deeper in the water column, suggesting that spawning may occur at or near bottom.[2,24] From a distance fresh veils reported to appear pale orange (est. 8–12 hr. old) [1] or

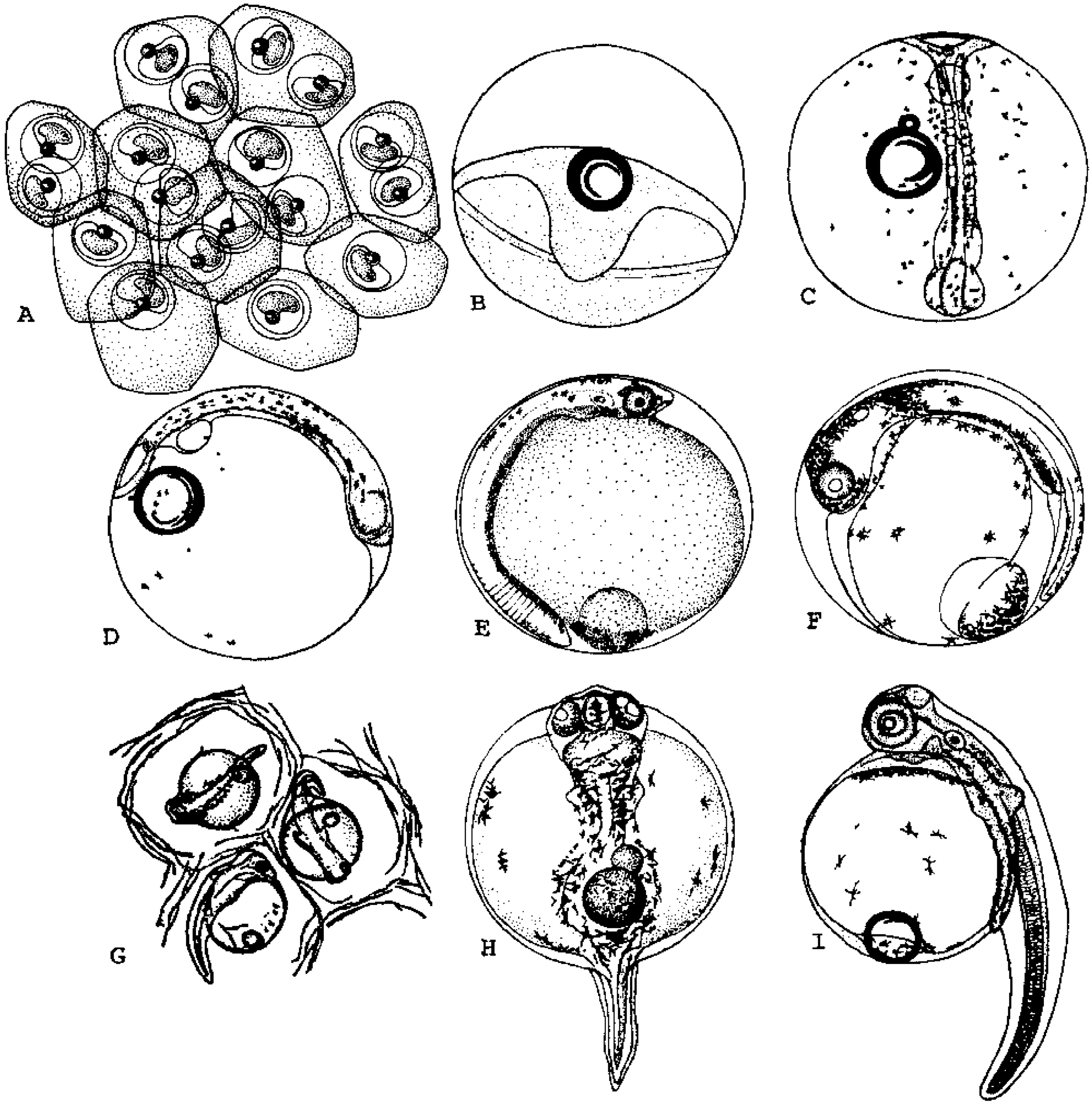


Fig. 188. *Lophius americanus*, Goosefish. A. Eggs in chambers of mucous "veil," germ ring stage. Only a small portion of veil drawn. B. Egg, germ ring stage embryo. C. Egg, 16–17 somite stage embryo, Kupffer's vesicle formed, dorsal view. D. Egg, 16–17 somite stage embryo, lateral view. E. Egg, tail-free stage embryo. F. Egg, prehatching stage embryo. G. Yolk-sac larvae still in mucous chambers after hatching from chorion. H. Yolk-sac larva, 2.5 mm TL, newly hatched, ventral view. I. Yolk-sac larva, 3.9 mm TL. (*A, H, redrawn from Procter, W.*, et al., *1928: figs. 1, 7. B-D, I, Berrill, N. J., 1929: figs. 3–6. C, D, retouched, I reversed. E, Bigelow, H. B., and W. C. Schroeder, 1953: fig. 285b. F, Tåning, A. V., 1923: fig. 14. G, Bigelow, H. B., and W. C. Schroeder, 1953: fig. 285a, after Agassiz, A., 1882.*)

chrome orange (est. 20 hr. old)[14] due to yolk color, pinkish on closer view. Older veils purple or lavender after embryos become pigmented.[1]

Fertilized eggs: Isolated eggs collected in the plankton with diameters 1.45–1.53 mm (formalin preserved) have been attributed to this species.[15,19] At germ ring stage living eggs slightly oval, major axis 1.61–1.86 mm, minor axis 1.56–1.63 mm.[1,2,14] Just before hatching eggs (from one of the same sets) somewhat larger, major axis 1.79–1.94, minor axis 1.72–1.74 mm.[1] Oil globule single, condensing from several droplets in ovarian stages,[2,28] or after fertilization;[24] its diameter (in vivo) 0.40–0.45 mm,[2,14] (in formalin) 0.37;[28] its color copper, orange or pinkish.[1,19]

EGG DEVELOPMENT

Reports based on collected eggs of unknown age. Reports of hatching vary, from soon after lens vesicle becomes distinct (ca. 2.5 mm TL)[1] to just before eye pigmentation complete (ca. 4.5 mm TL),[14] a 3 day discrepancy at 14–15 C. Confusion evidently resulting from fact that yolk-sac larvae remain for some time within chambers in the mucus.[2,24] If 2.8 mm TL selected as a standardized hatching size, development time from germ ring stage to hatching can be approximated as about 12 days at 10–11 C,[14] 7 days at 12–14 C,[26] 5 days at 14–15 C,[1] and 4 days at 15–16 C.[14] Following same convention: first pigment forms along neural cord about minus 4 days at 14–15 C;[1] Kupffer's vesicle and 16–17 somites about minus 10 days at 10–11 C and minus 2 1/2 days at 16–17 C;[14] tail-free stage and blastoderm covering yolk about minus 3 days at 12–14 C,[26] and minus 2 1/2 days at 14–15 C; heart beating and lens vesicle visible about minus 2 days at 14–15 C; lens vesicle clearly defined, growth of pectorals and cerebral vesicles beginning about minus 1 day at 14–15 C;[1] pectorals functional and eyes strongly pigmented at standardized hatching time (day 0) for all temperatures (GED, extrapolated from literature cited).

Pigmentation: At tail-free stage dense pigment along dorsal side of head, down in front and a little in on the ventral side (moving upward in the course of growth); medullary groove unpigmented; behind auditory organ pigment spreads downward connecting with a band of pigment along the sides of the alimentary canal (this connection later interrupted); vitellum with dense pigmentation near the embryo extending somewhat anterior to head and posteriorly toward the oil globule, which has a spot of dense pigment; caudal pigment diffuse at first, separating from the anterior pigment after tail-free stage.[2]

YOLK-SAC LARVAE

Hatching length: Reports vary (see egg development) from 2.5 mm TL[1] to ca. 4.9 mm TL.[14] "Embryos" figured by Agassiz[13] have left the chorion and are therefore yolk-sac larvae in the size range 2.5–4.5 mm TL (GED). Size at end of stage 6.5 mm TL[1]–7 mm TL.[27] Duration of stage 6–7 days at 14–21 C.[1]

Yolk initially almost spherical, 1.58–1.62 mm in diameter at hatching, oil globule near posterior wall. Cerebral vesicles well differentiated ca. 2.8 mm TL. Further brain and pectoral fin development and noticeable darkening of the eye within the next 24 hours at 15–16 C. From ca. 3.5–4.0 mm TL growth rapid, intestine convoluting, a notch developing in the dorsal finfold and pelvic fins appear. At 4.5–5.1 mm TL tip of second dorsal spine apparent in the dorsal notch, caudal part of body straightened, and mouth cartilages developing, yolk absorption also noticeable. Soon afterward pelvic fins shift forward under pectorals and lengthen, otic vesicle becomes visible. At 6.1–6.7 mm TL pelvic fins angled downward below lower edge of yolk sac, lower jaw conspicuous as mouth begins to open, yolk nearly absorbed. End of stage marked by appearance of the third dorsal spine, differentiation of the anus, and completed yolk absorption.[1]

Pigmentation: Diffuse caudal pigmentation of embryo (yolk-sac larva, GED) differentiating into 3 characteristic bands ca. 4.0 mm TL. At 4.5 mm TL dense melanophores form a cap on head above eyes extending back to the dorsal spines, a lateral band along junction of flank with yolk sac from posterior angle of jaw almost to vent, a scatter of melanophores on anterior and posterior surfaces of yolk sac, and a dense cap over oil globule in posterior part of yolk. In a few specimens (10 of 220) detached chromatophores were observed at notochord tip, or between or in front of the 3 strongly marked caudal pigment bars.[2] Pelvic fins develop dark pigment distally at ca. 5 mm TL, and a second, median band at 6.1–6.7 mm TL.[1] The 3 caudal bars and 3 ventral fin bands are lacking at comparable stages of the European *Lophius piscatorius*.[2,14]

LARVAE

Specimens described 6.5[1]–10.5 mm TL.[2] End of stage before 12 mm TL (GED). At 6.1–6.7 mm TL D. II, V. 1, finfold arched behind the dorsal spines. Pelvic fins (previously with only one ray, the third) add another ray (the fourth) about a day after third dorsal spine appears. Length of aquarium specimens decreases to 5.6–6.2 mm TL and after this development stops.[1] Field-collected specimens had second, third, and fourth dorsal spines at 6.5 mm TL, bases of first, fifth and sixth spines developing; V. 2–3; pectoral rays noticeable; hypural plate developing;[2] notochord very straight; teeth well developed on lower jaw.[13] At 8.0 mm TL D. IV (the fifth spine added); V. 2–3.[28] At 8.5 mm TL D. V (the sixth added); rays of soft dorsal and anal fins forming as thickened finfold; V. 5; C. 8 with rays fully formed, all hypochordal;

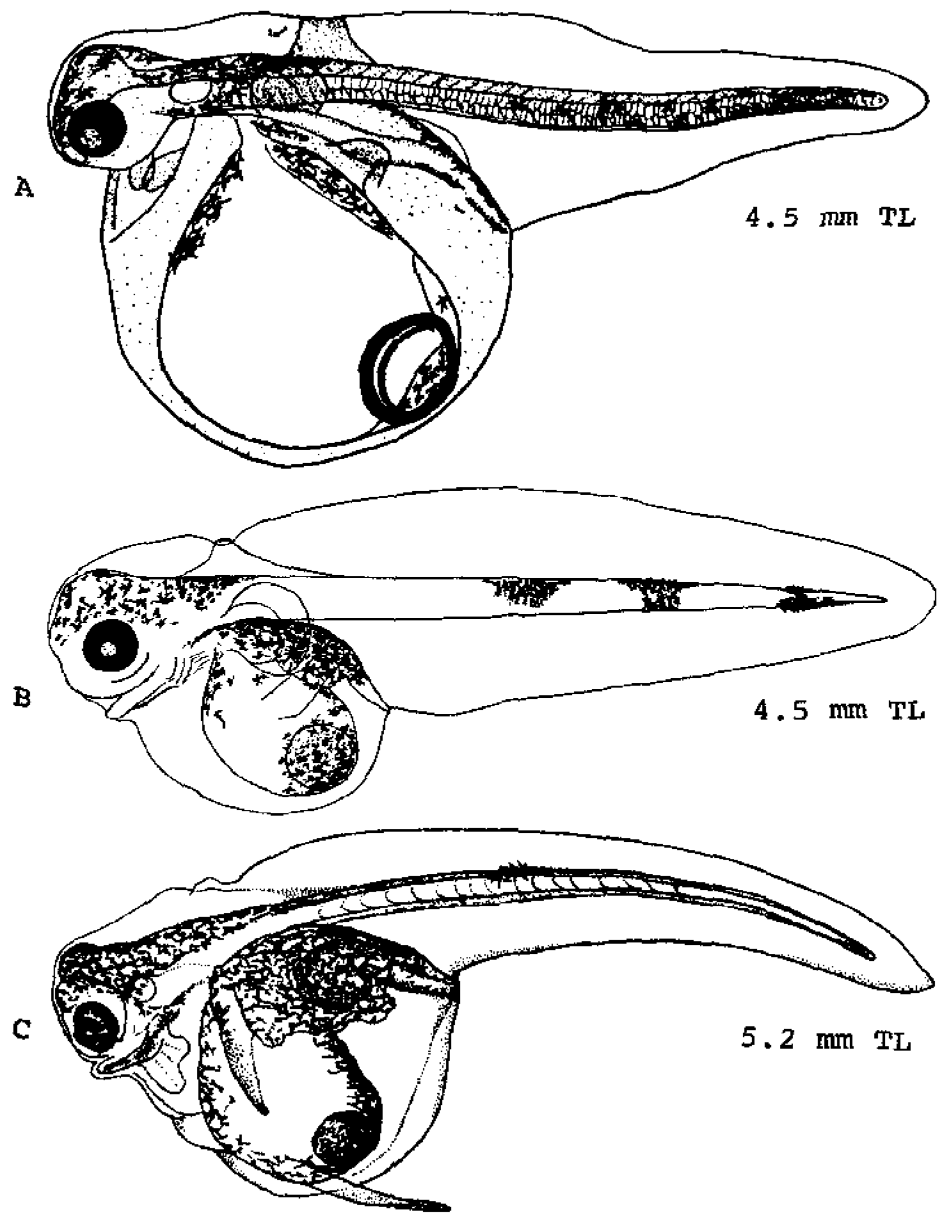


Fig. 169. *Lophius americanus*, Goosefish. A. Yolk-sac larva, 4.5 mm TL, just emerged from mucus. *B.* Yolk-sac larva, 4.5 mm TL, age unknown. C. Yolk-sac larva, 5.2 mm TL, ca. 5 days after hatching. (*A, Berrill, N. J., 1929: fig. 7, retouched. B, Tåning, A. V., 1923: fig. 17. C, Procter, W.,* et al., *1928: fig. 13, reversed and redrawn.*)

notochord still straight to tip (GED). At 9.0 mm teeth in both jaws.[28] At 10.5 mm TL first dorsal spine a small process forming in a hollow just in front of second, almost directly over eye center; dorsal and anal rays countable, V. I, 5; notochord flexion still not evident.[2]

Pigmentation: The three larval pigment bars are very visible in all the stages we have up to about 16 mm TL.[2] Rows of light gray dendritic pigment cells along *the lines of the embryonic pectoral rays (stage when D.* II, corresponding to 6.5 mm TL [1]). In the next stage figured (D. III, corresponding to 6.5 mm TL [2]) the dendritic stellate chromatophores of the head and of the ventral region of the pectoral side of the body are more numerous; the head is colored light yellow; the muscular bands and the tissues below patches of chromatophores along the body line are of the same color. The broad flat fin rays, dorsal and ventral, are of a grayish tint; the eye *is blue.*[15] *At 9.0 mm 3 characteristic larval pigment bars*

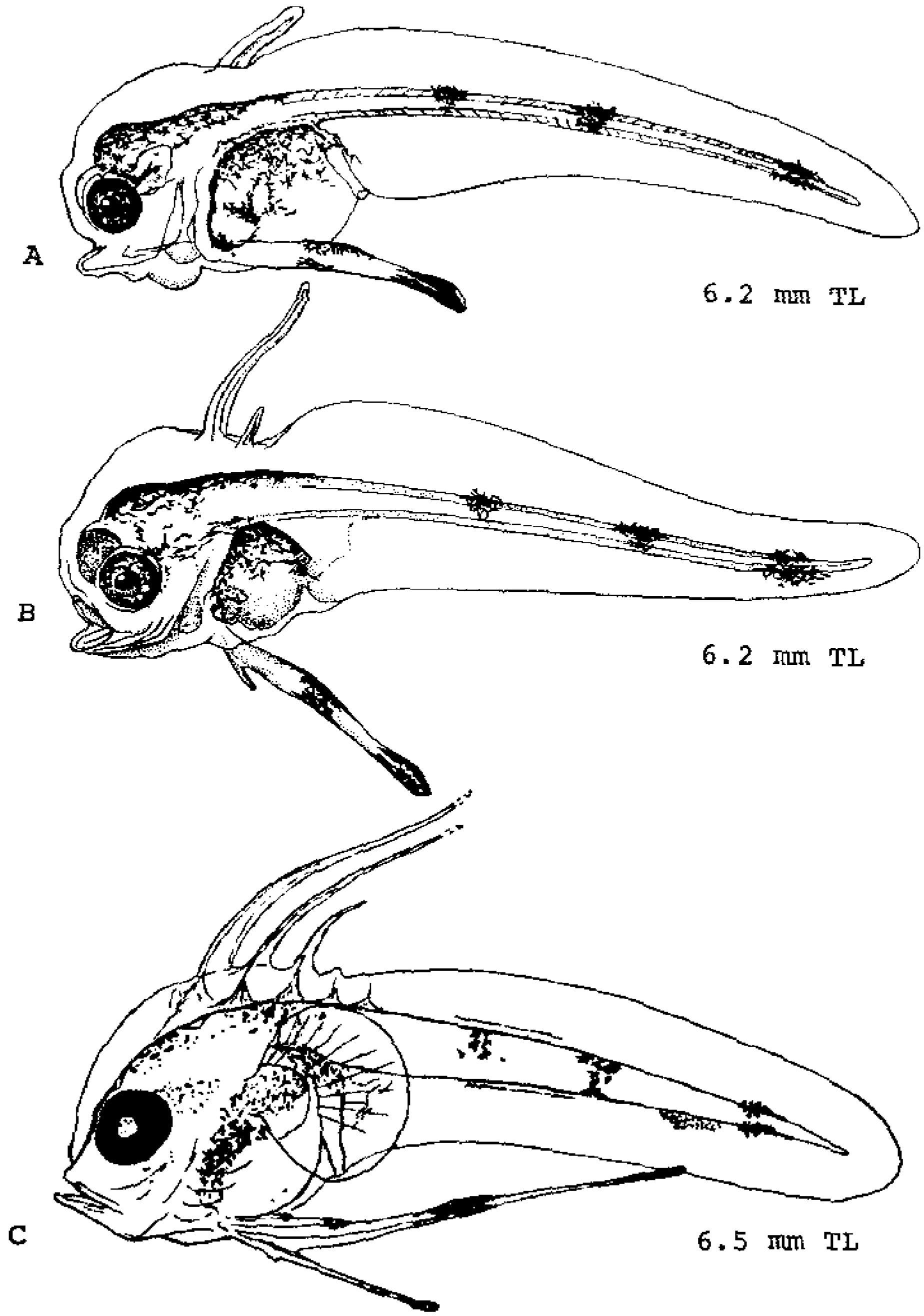
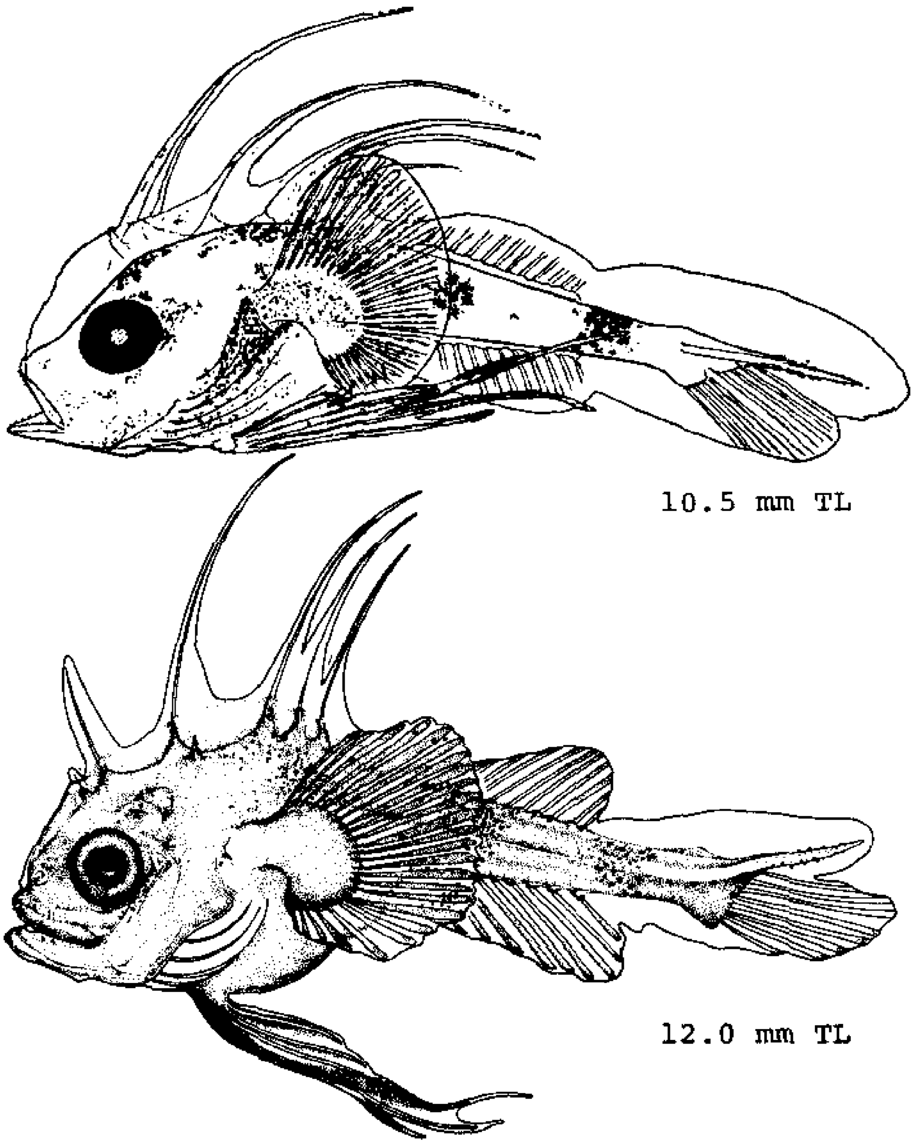


Fig. 190. *Lophius americanus*, Goosefish. A. Larva, 6.2 mm TL, ca. 7 days after hatching. B. Larva, 6.2 mm TL, ca. 9 days after hatching. C. Larva, 6.5 mm TL, age unknown, note position of developing hypural plate. (*A, B, Procter, W.*, et al., *1928: figs. 15, 20, reversed and redrawn. C, Tåning, A. V., 1923: fig. 19.*)



A

10.5 mm TL

B

12.0 mm TL

Fig. 191. *Lophius americanus*, Goosefish. A. Larva, 10.5 mm TL. B. Prejuvenile, 12.0 mm TL. Ventral surface of left pelvic fin is shown. (*A, Tåning, A. V., 1923: fig. 20. B, Original drawing by Elizabeth Ray Peters.*)

still present. The dorsal portion and the region of the body covered by the pectoral fins are also heavily pigmented.[28]

PREJUVENILES

Specimens described 12 mm TL (GED)–52 mm TL.[27] A questionable specimen 59.4 mm TL[8] not included. End of stage ca. 55–65 mm TL.[2,36]

Complete fin ray count established by 12 mm TL with external emergence of the first dorsal spine (GED). Available data inadequate for detailed morphometrics, but examples agree generally with *L. piscatorius*,[2,11,28] whose greatest width (at back of head, as percent of SL) increases from 23% at 11.3 mm TL to 53% at 44.8 mm TL then stabilizes about 50%, while greatest depth (at same point, inclusive of subepidermal space) increases from 38% at 11.3 mm TL to 50% at 44.8 mm TL, then decreases *to 40% at 60 mm TL.*[2] *Thus laterally compressed* larval shape changes gradually during this pelagic stage toward dorsoventrally compressed shape of juveniles and adults.[29]

Dorsal spines elongate and flexible, but, except for the first dorsal spine, their relative lengths remain comparable to the final configuration in adults.[28] Between 10.5

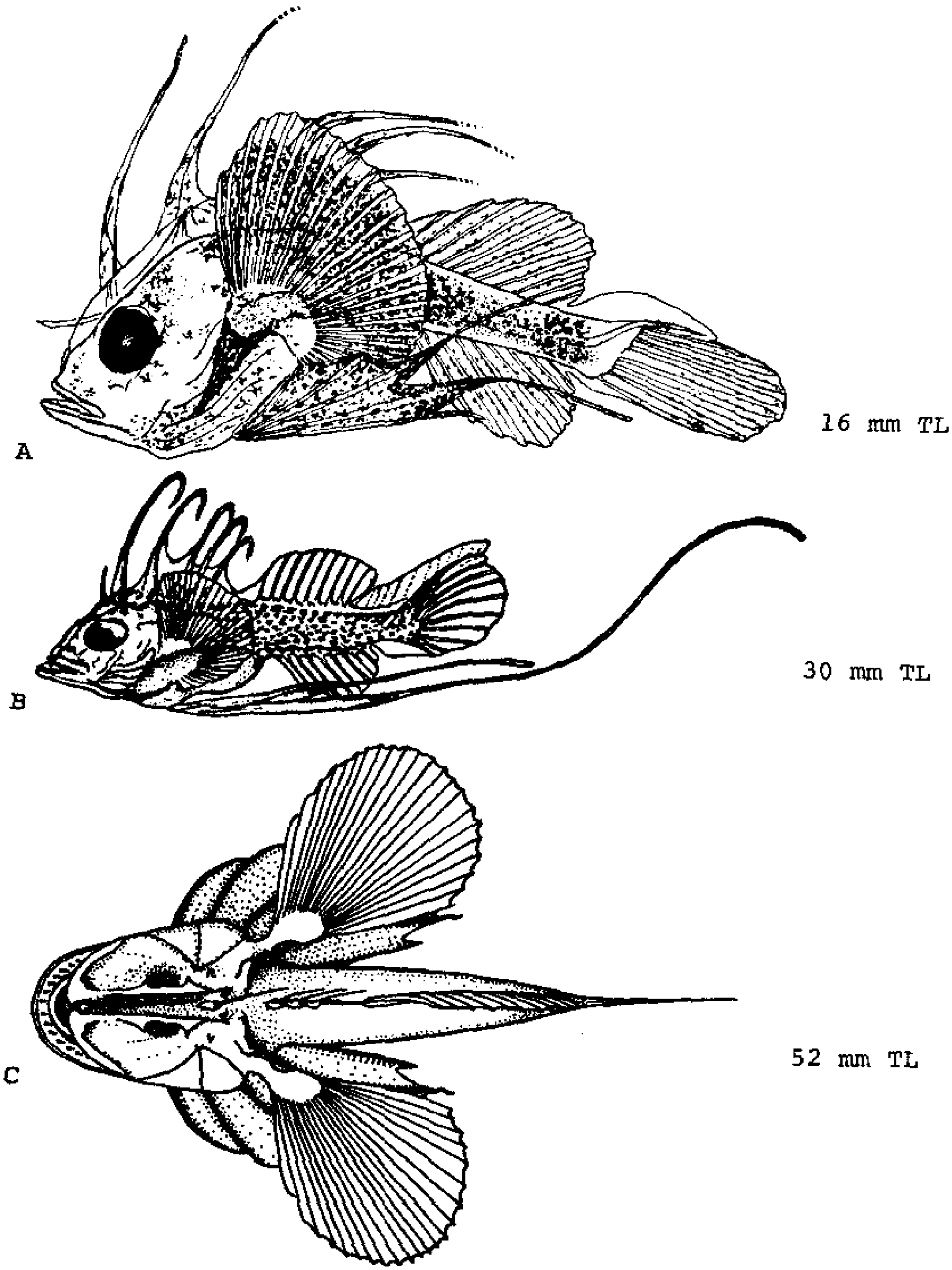


Fig. 192. *Lophius americanus*, Goosefish. A. Prejuvenile, 16 mm TL. B. Prejuvenile, 30 mm TL. C. Prejuvenile, 52 mm, dorsal view. (*A, Tåning, A. V., 1923: fig. 21. B, Bigelow, H. B., and W. C. Schroeder, 1953: fig. 265f, after Agassiz, A., 1882. C, Eaton, T. H., 1942: fig. 1.*)

and 12 mm TL first spine appears beyond epidermis, its length ca. 1 mm at 16 mm TL,[2] 4 mm at 26 mm TL,[28] 7 mm at 36.5 mm TL,[2] and 9 mm at 52 mm TL.[11] Pectoral fins very large throughout stage, held expanded outward from body, each one wider and longer than head.[2,11,13,28] At 12 mm TL all median fins extending beyond finfold, all fin rays present and countable, 6 well formed pelvic elements (GED) not 5 as reported for 30 mm TL [13] nor 3 plus 2 "buds" at 26 mm,[28] although spine and first ray closely approximated, as reported for adult.[25] Third and fourth pelvic rays and, to a lesser extent, fifth ray greatly elongate, third (the longest) reaching to caudal peduncle at 16 mm TL,[2] slightly beyond tip of caudal fin at 26 mm TL,[28] twice as long as body at 30 mm,[13] but receding (or possibly damaged) in specimen of 52 mm TL, not reaching caudal peduncle.[11] Upward flexion of notochord only about 15° at 12 mm TL (GED). Three pairs of prominent post-orbital spines throughout stage.[28]

Pigmentation: At 10.5 mm TL still shows larval pattern.[2] At 26 mm TL the entire body, except the ventral surface between the anal fin and the origin of the pelvic fins, is mottled with dark brownish dendriform pigment spots. The caudal fin is only slightly pigmented along its rays.[28] At 30 mm general color of body very light, dirty violet tint, olive green along the dorsal line; body and head covered by darker violet gray spots. Pigment spots in pelvics intense black, as well as a few of the spots along the extremity of the notochord. Violet gray spots numerous along pectoral rays, with rows of darker cells at their base. Dorsal, anal and caudal still very transparent, with a delicate violet tinge.[13] "At 36.5 mm TL the 3 larval pigment bars are effaced from the pigment, which has now greatly increased ... strongest in the abdomen, on the body above and just behind the pectoral fins, and on these and the ventral fins. The posterior pigment bar, which lies about the tip of the notochord, is, however, still present in the form of small melanophores." [4]

JUVENILES

Specimens described 76–133 mm TL.[7,10,28]

At 76 and 112 mm TL pectoral fins membranous, winglike and comparatively wide, 31 mm in 76 mm TL specimen; pelvic fins long, narrow, extending 34 mm parallel to body axis. At 112 mm TL paired fin rays softer, with less rigid and flaring appearance. At 133 mm TL paired fins have undergone a pronounced change, pectorals are flipper-like, pelvics broadened with strongly developed rays, directed now backwards and outward, crossing over axis of pectorals. Three rows of depressible, inward curving teeth present on jaws. Head one-third length of the body.[7,28] Pigmentation not described.

AGE AND SIZE AT MATURITY

Information not extensive, suggested to be 4 years for males, 5 years for females.[7]

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Histrio histrio
Phrynelox scaber

frogfishes
Antennariidae

FAMILY ANTENNARIIDAE

The pediculate family Antennariidae includes fishes popularly known as frogfishes. Opinion on the number of species varied in two books published the same year from 45 (Randall, 1968) to 65 (Böhlke and Chaplin, 1968). Schultz (1957) listed 58 species in 13 genera. One of these, *Kanazawaichthyes,* was indicated by Hubbs (1958) to consist of pelagic prejuveniles of *Antennarius,* much better known as adults. Antennariids are distributed in shallow waters of all tropical seas, with a few species entering temperate waters. About nine western Atlantic species are recorded. No concensus exists on exact demarcation of genera; this treatment follows Schultz (1957) and Böhlke and Chaplin (1968) in nomenclature of the two species included.

Juvenile and adult frogfishes apparently feed primarily on fishes and most can take prey up to their own size or somewhat larger. Able to swim, at least for short distances, they spend most of their time motionless on or attached by means of their mobile paired fins to substrates. Although they sometimes stalk prey, their basic feeding strategy seems to be ambush, either of chance passers-by or of fishes lured into striking range by motion of the illicium, a structure described below. Away from natural surroundings their colors and patterns appear striking, but in most forms the blend with the background is said to be very close.

As in other members of the order studied, frogfish eggs are laid in large, buoyant masses with various shapes depending on the species. Yolk-sac larvae are quite small and float yolk uppermost until yolk reserves are depleted. The larvae are likewise small compared with many fish larvae and develop adult fin ray complements before much change in length occurs. A pelagic prejuvenile phase is well defined (Hubbs, 1958) and probably provides most of the dispersal that takes place during the life cycle.

Members of the family can be recognized by their globular, somewhat amorphous body shape which is compressed rather than depressed like the related families Lophiidae and Ogcocephalidae; by their more or less roughened skin studded with minute denticles; by a very restricted gill opening near or slightly behind the pectoral fin base; their first gill arch with poorly developed gill rakers and greatly reduced or no gill filaments; their large, almost vertical mouth with small conical teeth in rows on jaws, vomer, palatines and tongue; and by their dorsal spines, of which the third and second are separate and often covered with skin, the first set well forward on the snout and modified into a fishing lure, with an illicial rod of variable length terminated in a fleshy "bait" or esca. (Schultz 1957, terminology of the illicium after Bradbury, 1967.) An air bladder is present in most of the species (TWP).

Histrio histrio (Linnaeus), Sargassumfish

ADULTS

D. III–11–13 (mode 12); A. 7–8 (mode 7); P. 9–11 (mode 10); [16] V. 5; C. 9; [23] vertebrae 18 [33]–19; [15] 10 precaudal, 8 caudal.[33]

As a percentage of SL: Head 44–50, depth 56, pelvic fin length ca. 25.[22,24]

Body short, thick, somewhat compressed laterally, caudal peduncle free; [23] head large; mouth relatively small and oblique when closed, gape very wide; oral breathing valves well developed; jaw teeth in villiform bands; palatine teeth present; [21] lower limb of first gill arch with filaments along its entire length; [19] external gill apertures reduced to small openings in pectoral axils.[20,22] Air bladder poorly developed, not discernible in all specimens (TWP). Skin smooth to the touch, actually with minute granulations; variously shaped cirri on sides, most numerous on abdomen; [21] two characteristic cirri on midline of snout in front of first dorsal spine.[19] Fins fleshy, covered with thick skin; paired fins slender and freely mobile; pectoral base elbowed and arm-like, supported by three radials,[15] the fin hand-like, prehensile, able to grasp plant fronds; [19,22] pelvic fins long, well developed, reaching anal origin; [17,24] three spines preceding soft dorsal; the first slender, standing over the anterior margin of the eye, its tip (esca) expanded and fringed, forming a lure or bait; [21,22] second and third spines much longer than first, depressible,[2] and encased in skin bearing fleshy cirri or streamers; soft dorsal fin more than twice as long as anal fin; margin of caudal fin slightly convex; ends of all fin rays extended beyond membrane to form fringes.[23]

Pigmentation: Color creamy white to yellow, mottled on head, body and fins with light and dark brown, pattern highly variable. Body color extended on iris to margin of pupil; three dark bands radiating from the eye. Small round spots and irregular thin lines of white superimposed on ground colors, similar to epiphytic growth on sargassum leaves and stems. Cirri yellowish. Tongue and floor of the pharynx to fourth branchial arch marked with mottled brown and white, simulating the external pattern. Very changeable in shade, darkening when disturbed, lightening against light backgrounds.[20,21,23]

Maximum length: In Atlantic 106 mm SL (140 mm TL). In Pacific 140 mm SL (195 mm TL).[11] Record of 381 mm [18] undocumented, doubtful (GED).

DISTRIBUTION AND ECOLOGY

Range: Tropical and subtropical Atlantic, Pacific and Indian Oceans; [11,19,23] rare in west African waters.[9] Extreme northern records for Atlantic at Vadso, Norway [23] and at 43° 18′ N, 55° 50′ W off Grand Banks.[7]

Area distribution: New Jersey to Virginia,[11] Chesapeake Bay.[25]

Habitat and movements: Adults—near the surface among floating seaweed, usually attached by means of the hand-like pectoral fins.[20] Not a strong swimmer, movements very dependent on the major ocean circulation patterns, on the temperatures below which sargassum gradually loses buoyancy,[31] and occasional sustained, strong winds that carry seaweed away from its normal patterns of drift.[3,29] Occurrence evidently seasonal in Japan, few or no individuals appearing in the drifting seaweed from November through April.[27,28] In the Florida Current off Key Biscayne, Florida, adults absent or poorly represented in samples June–August and October–December.[26] Temperature range, 18.2–33.6 C; salinity range 25.5–37.9 ppt.[34]

Yolk-sac larvae—floating, yolk uppermost (LAK).

Larvae—from surface down to 600 m depth in Florida Current. Of 17 larvae in the size range 1.9–4.4 mm SL (ca. 3–7 mm TL) from various collections, depth was given as 0 (surface) for four larvae, and included 50, 75, 100, 125, 300, 350, 400, 500, and 600 m depths for 13 others (2.1–4.4 mm SL). Some of the larvae at the greater depths had food in their stomachs.[5] There is at least a suggestion that dispersal within the current might be accomplished by sinking to slower-moving layers of the current for some period (GED). Dates of capture were clustered in the months November–February, June, and August, with some indication (making allowance for small sample size) of reduction or hiatus in April–May and again in October.[5]

Prejuveniles—in contrast to larvae, depth distribution in the foregoing study was listed as 0 (surface) for 13 prejuveniles 5.0–15.2 mm SL (ca. 7.3–20 mm TL), and as 25 m for one specimen 14.9 mm SL.[5] Including collection dates for these with a much larger sample taken by Dooley,[26] Florida occurrences for 5–15 mm SL individuals are well represented in October–May and less frequent in June–September. In 1967, smaller specimens (5–10 mm SL) became scarce about a month earlier (in May) than 10–15 mm SL specimens. In the Gulf Stream off South Carolina, prejuveniles were taken in all four seasons south of Charleston, but only in October north of Charleston.[6] In Japan 11–16 mm TL specimens were collected only in May and August.[27]

Juveniles—individuals 15–50 mm SL are found in the same habitat at the surface as adults.[5,26,27,28,32]

They were represented in Florida collections during

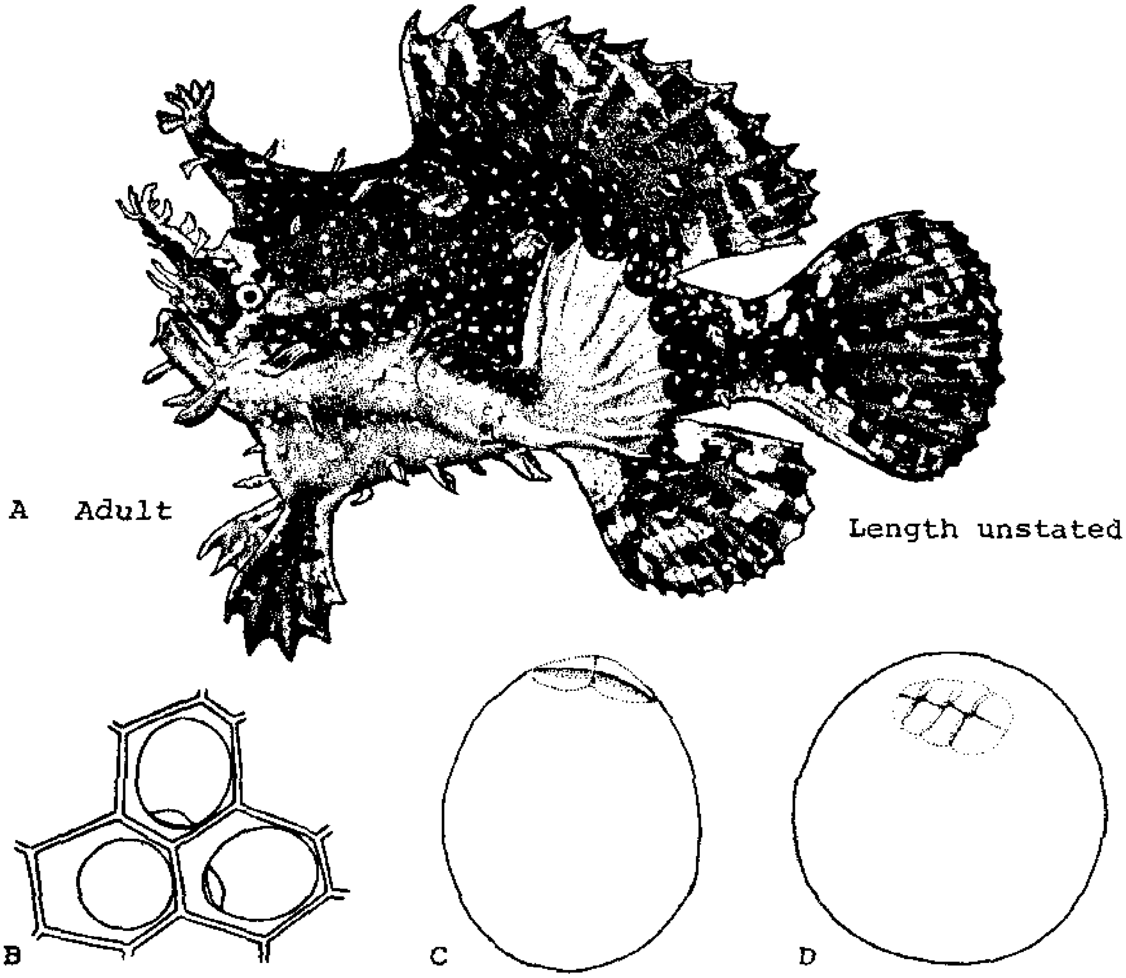

Fig. 193. *Histrio histrio*, Sargassumfish. A. Adult, length unstated. B. Diagramatic figure of fertilized eggs in raft, before first cleavage. C. Egg, 2-cell stage. D. Egg, 8-cell stage. (*A, Jordan, D. S., 1905: fig. 500. B, Fujita, S., and K. Uchida, 1959: fig. 1. C, D, Mosher, C., 1954: figs. 1, 3, delineated by Joan Ellis.*)

every month except October and were most abundant June–September, abruptly disappearing for one month and reappearing in reduced numbers through the winter months. They were generally less consistent in representation than prejuveniles.[26] In the Gulf Stream they were taken in May and less commonly in October, but were not taken in summer or winter cruises.[6]

SPAWNING

Location: Spawning assumed to occur in clumps of sargasso weed drifting in the open ocean. Since adults are normally intolerant of one another except during courtship, a minimum migration by one sex or the other (probably males) from clump to clump must occur for pairing. Fertilization occurs in a brief (0.4–10 sec) period at the surface following a quiescent courtship lasting from several hours to more than a day. In aquaria pairs remain together through several spawnings at 3–6 day intervals.[2] Size distribution of young taken in the Florida Current indicates that the current east of Florida is a major spawning area.[5,26]

Spawning season: Well-fed females maintained in the laboratory have produced eggs every few days over periods of 2–4 months, with or without males present.[1,2,14] A suggested interruption of larval occurrence during April and May in Florida may reflect a reduction of spawning activity there in February and March, traceable to reduced water temperatures.[5] A second apparent hiatus in October seems to be associated with reduced occurrence of large adults in middle to late summer,[26] which could in turn reflect reduced survival or growth during the preceding winter in northern or eastern legs of the Sargasso Sea circulation.[30,31] Florida Current spawning activity thus seems loosely concentrated in two peaks, one in May and June, the other beginning in October and continuing until about January (GED). Juveniles appearing further north in the Gulf Stream in October and May [6] provide additional evidence for summer and winter spawning peaks, respectively.[1,2,12,14]

Time: 1600–2030 hours for numerous laboratory spawnings.[1,2,12,14]

Temperature: Not closely correlated, about 24–30 C for the months indicated.[5,26]

Fecundity: No exact information on eggs per spawning, "thousands" of ova,[1] females produce egg rafts at intervals of 3–9 days for 2–4 months when well fed.[1,2,4,14]

EGGS

Location: When liberated, eggs embedded in a buoyant raft of mucoid, gelatinous material which is transparent and glass-like in appearance. Freshly spawned raft ca. 89 mm in length, 25–50 mm wide, with scrolled ends coiled upward and inward to its middle, lacking the flat central portion described for related genera.[1,2] Eggs arranged in 2–3 [14] or several [2] layers, each egg usually separated from the others by well defined membranes forming a polyhedral compartment, in which the egg is free to rotate.[2,12] Females, as they aged in the laboratory, were observed to produce rafts in which two or even three eggs per compartment became more frequent.[1]

Unfertilized eggs: After ovulation "the egg mass lies close packed in the ovary like a bank note tightly rolled up from its two ends." [20] Eggs when laid colorless, approaching transparency; without oil droplets; the germinal disc partly sunk in a depression in the yolk, half its thickness being below the yolk surface, the depression entirely filled with protoplasm; a single nucleus visible in optical section.[8]

Fertilized eggs: Oval [2] or elliptical; major axis 0.62–0.65 mm [12] or 0.7 mm,[2] minor axis 0.53–0.57 mm [12] or 0.6 mm; becoming spherical at the time of the second cleavage; ova extremely transparent, glassy.[2]

EGG DEVELOPMENT

Development: As development proceeds raft unrolls and expands to a length of 300 mm [1]–900 mm,[24] a width of 51 mm [1]–76 mm, and a thickness of 8.2 mm [24]–16.4 mm.[17] The membranes remain firm until about the 6–11 myomere stage, then begin to deteriorate, the raft softening and expanding to about three times its original dimensions, and finally beginning to sink.[2,12]

At 21–23 C, developmental steps as follows (Atlantic): [2]

1—one cell; depth of disc at animal pole 0.3 mm; 0–2 hr.
2—two cells; cleavage complete; 2 hr.
3—four cells; second cleavage complete; 3 hr.
4—eight cells; third cleavage complete; 4 hr.
5—morula; cells spreading; 5.5–10 hr.
6—late blastula; beginning of germ ring; 21–27 hr.
7—germ ring; beginning of embryonic shield; 27–36 hr.
8—embryonic shield thickened and lengthened; 36–40 hr.
9—neural crest formed, its average length 0.3 mm; 40–48 hr.
10—optic vesicles and three to four somites formed; length 0.5 mm; ca. 40 hr.
11—increase in number of somites, before 65 hr.
12—optic lens and auditory placode formed; thirteen to fifteen somites; tail free; length 0.6 mm; 65–75 hr.
13—heart beating strongly; tail twitches sporadically; 90–96 hr.
14—hatching; pectoral fins developed, no pelvics; 1.4 mm, TL; melanophores on top of head and over eyeballs, a solid band in the dorsal peritoneum over top of yolk sac; 108 hr. (4.5 days).[2]

At 26.8–27.4 C, developmental stages compared to above (Pacific): [12]

1—one cell visible; 1 hr.
2—two cells; 1 hr. 20 min.
4—eight cells; 2 hr. 5 min.
5—blastula; 20 hr. 35 min.
6—gastrula, germ ring; 26 hr. 30 min.
8—neural crest forming; 32 hr. 5 min.
10—optic vesicles and Kupffer's vesicle formed; 35 hr. 30 min.
11—six somites formed; 37 hr. 20 min.
12—optic lens and otocysts formed; 39 hr. 30 min.
13—minute hexagonal or pentagonal networks "with small yellowish spots on the corners of the net" noted on the yolk surface just before hatching; 47 hr. 20 min.
14—hatching; melanophores absent; 48 hr. 20 min.

Rasquin,[1] comparing development to *Phrynelox scaber* and to steps described by Mosher,[2] added the following notes on development at ca. 30 C (Atlantic):

6—late blastula (=*Phrynelox* step 9), early germ ring; in some spawnings embryonic shield reached; ca. 20 hr.
7—germ ring (=*Phrynelox* step 14); embryo covers at least three-fourths of yolk; clusters of peculiar cells noted on ectoderm; ca. 36 hr.
12—optic lens (=*Phrynelox* step 16); gill slits developing; blastopore still open; ca. 40 hr.
13—prehatching; ca. 60 hr.
14—hatching (=*Phrynelox* step 17); with very little pigment, a few melanophores around the gut; ca. 72 hr.

Although Rasquin [1] did not maintain close control of temperature, development appears comparable for the first 40 hours between Atlantic and Pacific *Histrio histrio*

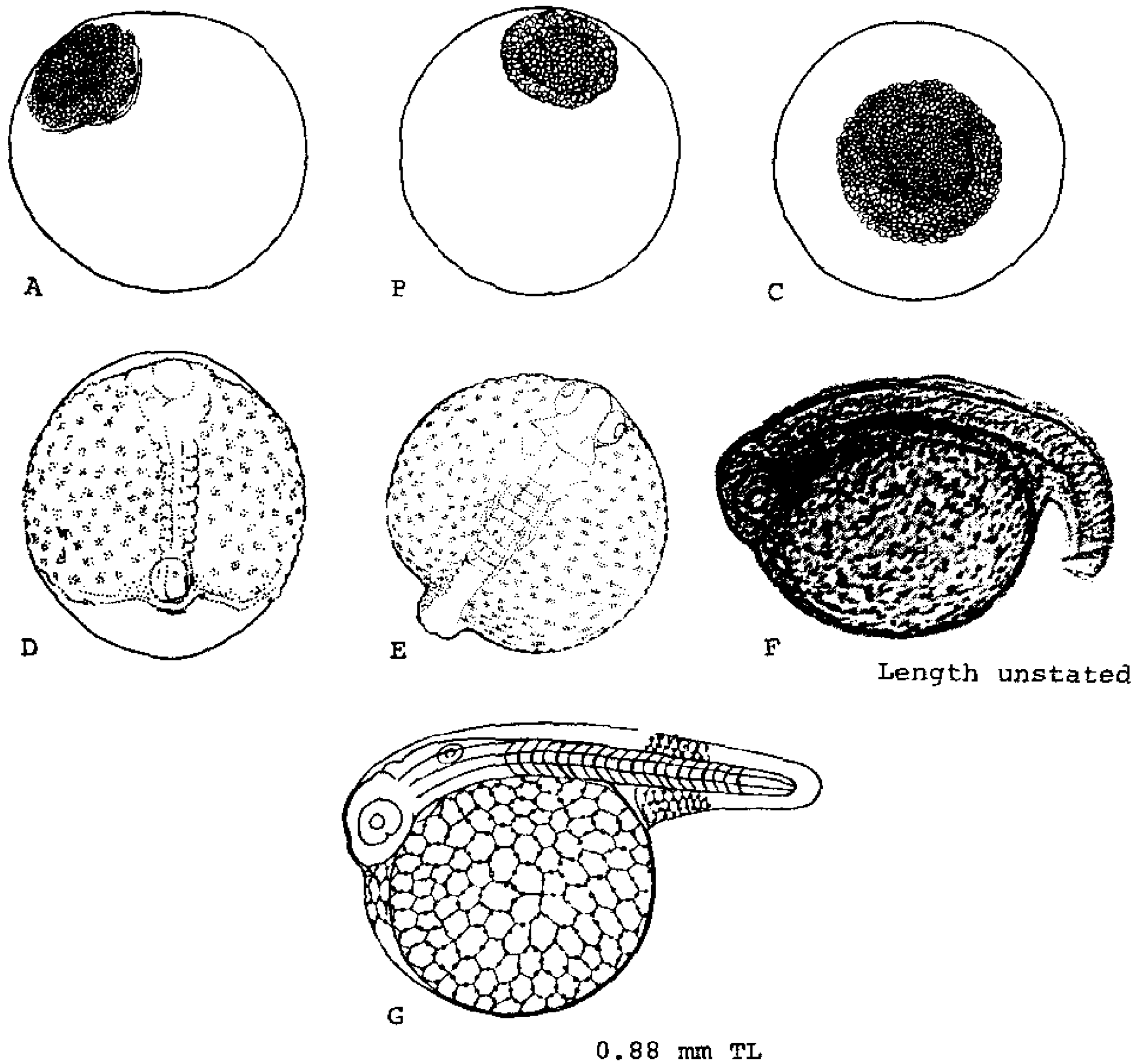

Fig. 194. *Histrio histrio*, Sargassumfish. A. Egg, late blastula stage. B. Egg, early gastrula, germ ring stage. C. Egg, late gastrula, embryonic shield forming. D. Embryo, 8 somites, Kupffer's vesicle present. E. Embryo, lens vesicles and auditory placodes formed, surface features of this and preceding embryo are not pigmented. F. Yolk-sac larva, length unstated, photographed while hatching. G. Yolk-sac larva, 0.88 mm TL, newly hatched. (*A, C, E, F, Rasquin, P., 1958: pl. 73, figs. 1, 3, 6, delineated by Joan Ellis; pl. 74, fig. 4. B, D, Mosher, C., 1954: figs. 4, 8, delineated by Joan Ellis. G, Fujita, S., and K. Uchida, 1959: fig. 12.*)

at 27–30 C, the hatching itself occurring earlier in the Pacific study.[12] Hatching reported to occur several hours earlier in eggs separated from the raft.[2]

YOLK-SAC LARVAE

Hatching length: 0.88–1.00 mm TL. Size at end of stage for laboratory hatched larvae ca. 1.7 mm TL;[12] ca. 1.6 mm with evidence of abnormally slow growth.[5] Duration of stage: (in laboratory) 4 days at 26.8–27.4 C,[12] 4 days at ca. 30 C.[1]

Yolk-sac larvae showed choroid fissure and "networks," as described above, on yolk and finfold.[12] Developmental steps described by Rasquin[1] as identical to those in *Phrynelox scaber* except for pigmentation, and the following (steps numbered as for *Phrynelox*):

17—day of hatching, pectoral fin bud formed, held closer

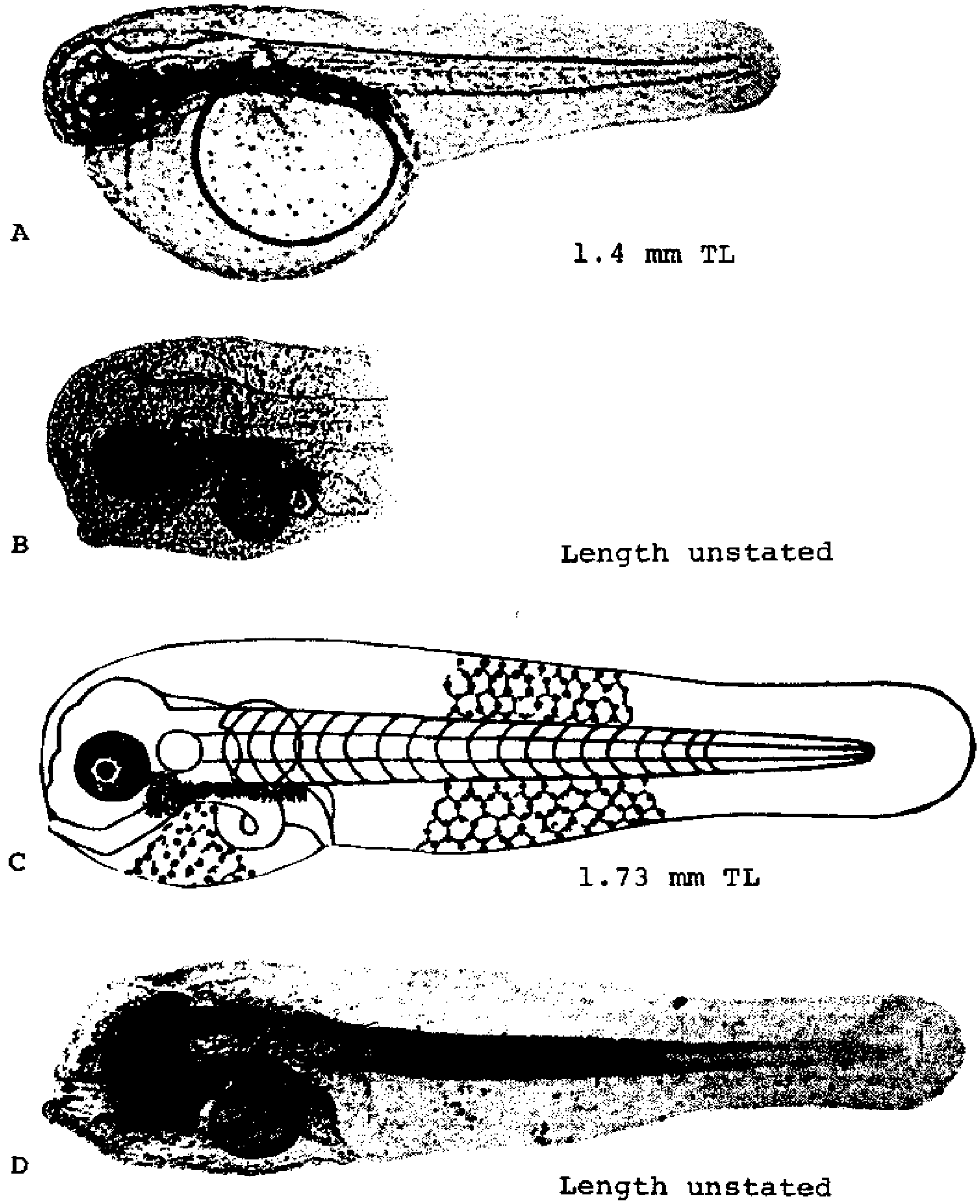

Fig. 195. *Histrio histrio*, Sargassumfish. A. Yolk-sac larva, 1.4 mm TL, 4.5 days postfertilization. B. Head of yolk-sac larva, length unstated, 7 days postfertilization. C. Yolk-sac larva, 1.73 mm TL, 4 days post-hatching. D. Yolk-sac larva, length unstated, 11 days postfertilization, stained to show cartilage. (*A, D, Mosher, C., 1954: figs. 10, 11. B, Rasquin, P., 1958: pl. 74, fig. 6. C, Fujita, S., and K. Uchida, 1959: fig. 13.*)

to the body than in *Phrynelox*, ca. 72 hr. (3 days) after fertilization.

22—a transient difference in *Histrio*, the brain strongly flexed downward on the anterior end so fish appears to have a very high, flat forehead. The eyes of *Histrio* are smaller and more nearly spherical, not flattened anteriorly as in *Phrynelox*. Mesenchyme forming six points on caudal end of finfold suggestive of fin rays. Myomeres are well formed and distinct lateral and ventral to the notochord. Time ca. 7 days after fertilization (3.5 days after hatching).[1]

Pigmentation: Except for a few melanophores around the gut, laboratory hatchlings at ca. 30 C had little pigment up to 95 hr. after fertilization (23 hr. after hatching).[1] Yolk-sac larvae in the Japanese study, which hatched earlier (48.5 hr.), had none.[12] At a lower temperature (21–23 C) "newly hatched" larvae (108 hr.) were reported to have melanophores covering the head and a solid band in the dorsal peritoneum across the top of the yolk sac.[2] At 116 hours after fertilization yolk-sac larvae at ca. 30 C showed considerable increase in pigment, particularly around the gut and in the choroid region of the eye; retinal pigment still extremely scarce. At the anterior end where pigment spreads out behind the eyes, the pattern of a "Y" seen in *Phrynelox scaber* is not present; dispersed melanophores fill in the acute-angle area. They also spread a little over the dorsal surface of the yolk, so the pattern is much less sharply defined than in *P. scaber*. Retinal pigmentation is completed at 168 hr. (7 days) after fertilization, 3 days after hatching.[1]

LARVAE

Specimens described ca. 1.6–6.9 mm TL. Size at end of stage ca. 7.2 mm TL. A transitional specimen 5.0 mm SL (ca. 7.3 mm TL) is described below as prejuvenile.[5] Duration of stage: no exact information, a rough estimate based on length-frequency distribution of small samples from several years [5,6,26] is one and a half to two months or more, depending on water temperature (GED).

Some aquarium-hatched larvae survived ca. 2 days after yolk absorbed, without further growth in length.[1] Sequence of fin development to definitive ray count is caudal, anal, soft dorsal, pelvics, pectorals, and finally dorsal spines.[1,5] Eight points present first day of stage on caudal finfold, with radially spreading mesenchyme approaching them.[1] Of 26 specimens 1.9–4.4 mm SL, 17 had 9 caudal rays countable, fin damaged in at least some of the others. Of 4 specimens 1.9–2.4 mm SL, only 1 had definitive anal count of 7 rays, other uncountable. Of 22 specimens 2.5–4.4 mm SL, 18 had 7 anal rays, 3 had 6 anal rays, 1 was uncountable.[5] Anlagen of first two dorsal spines could be seen before differentiation of soft dorsal or anal on last day of life in aquarium larvae,[1] but soft dorsal penetrates dermal envelope well before spines; of 4 specimens 1.9–2.4 mm SL, 1 had 11 dorsal rays, 1 had 10, 1 had 9 and 1 was uncountable; in 14 specimens 2.4–3.4 mm SL, dorsal count ranged 9–2, with one uncountable, formation evidently still in progress; in 8 specimens 3.5–4.4 mm SL, dorsal count was 11 or 12, apparently stabilized; pectoral rays were uncountable in larvae. Pelvic rays were counted as 5 in two larvae of 3.6 and one of 4.0 mm SL. Myomeres were not counted but were visible in caudal and lower dorsal regions of many but not all larvae studied.

As a proportion of SL: Preanal distance was a relatively constant 0.740–0.755 through larval stages when averaged for groups of 4 to 8 larvae; mean pre-soft dorsal length was variable from 0.485 to 0.789, but when averaged for the groups 1.9–2.4, 2.5–2.7, 2.9–3.4, and 3.5–4.4 mm SL, it decreased from 0.685 to 0.646, and to 0.561, then increased to 0.571, indicating a non-isometric growth pattern; head length (to opercle margin) for the same groups started at 0.408, increased to 0.449, decreased to 0.387, then increased to 0.418 (data grouping GED). Other proportions were studied, showing similar non-isometric trends in the larval stage.[5]

At 2.0 mm SL the head relatively large, forming one-third to almost one-half the body length in some individuals, the head parts also proportionately large at this stage. The head and constituent parts relatively smaller at 3.4 and 4.0 mm SL. The eye doubly notched at 2.0 mm SL; at 3.4 mm SL the lower notch (choroid fissure) still open. Eye round by 4.0 mm SL. Membrane of the soft dorsal develops after that of the anal and caudal fins, and is incomplete at 2.0 mm SL; the three dorsal spines visible under the integumentary envelope in some specimens and not in others; at 2.0 mm SL the first dorsal spine resembles the others; rays of the caudal fin figured as unbranched after 3.4 mm SL; in the 2.0 mm specimen the pelvic fin bud dimly visible through the expanded supporting structures of the gills, first appearing externally in 2.6 mm SL larva. At 2.0 mm SL (ca. 3.1 mm TL) the integument a more or less spherical, cellophane-like bubble, in contact only with the mouth, vent and fin bases; this begins to shrink and become opaque by 4.0 mm SL.[5]

Pigmentation: At 2.0 mm SL chromatophores are conspicuous in the head region, and especially around the eye. Pigmentation of the midgut is dense and dark. At 3.4 mm SL the chromatophore pattern on the head, around the eye, and on the postcephalic portions of the back is more complex, but the midgut pigmentation still prominent and dense. At ca. 4.0 mm SL there is increased chromatophore development in the cephalic and upper dorsal regions.[5]

PREJUVENILE

Specimens described 5.0–15.2 mm SL; one transitional at 5.0 mm SL and 14 ranging from 9.0–15.2 mm SL (ca.

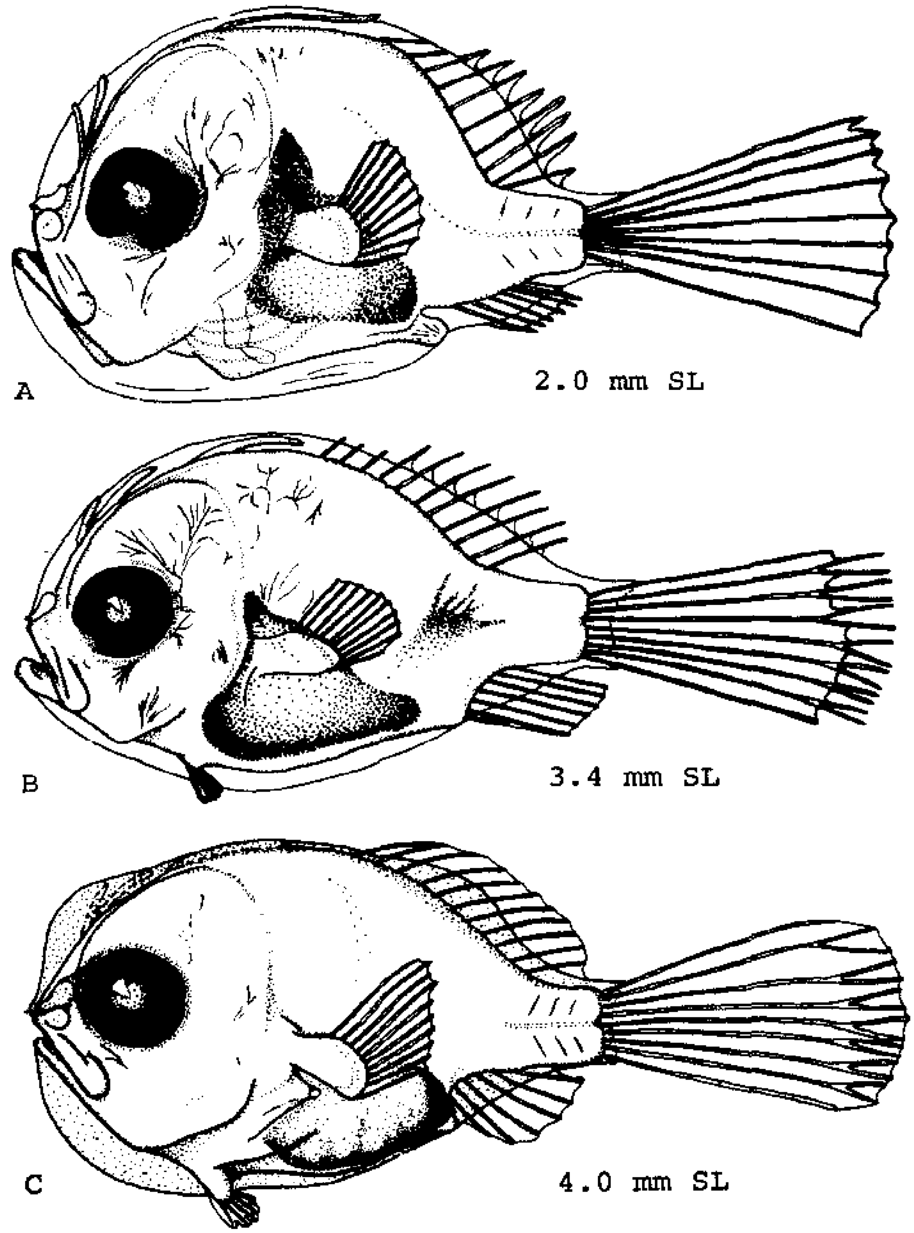

Fig. 196. *Histrio histrio*, Sargassumfish. A. Larva, 2.0 mm SL. B. Larva, 3.4 mm SL. C. Larva, 4.0 mm SL. (*A-C, Adams, J. A., 1960: fig. 1.*)

7.3–20.0 mm TL).[5] Duration of stage: estimated from length-frequency histogram [26] as lasting ca. two months (GED).

D. III, 10–12 (mode 12); one or two branched; A. 7, none branched; C. 9, 7 branched; P. 10, none branched; V. 5, none branched.[5]

As a proportion of SL: Mean head length 0.433 (0.322–0.487); mean pre-soft dorsal length 0.518 (0.487–0.617); mean preanal length 0.737 (0.684–0.810); mean prepelvic length 0.377 (0.240–0.472).[5]

At 5.0 mm SL some traces of the myomeres still present, the eye less conspicuous than in larvae; the tips of the dorsal spines externally visible as minute bumps; the pelvic fin bases still short but beginning to elongate; and the integumentary envelope thickened and wrinkled over the whole body. First and second dorsal spines externally discrete at 7.0 mm SL and the envelope has

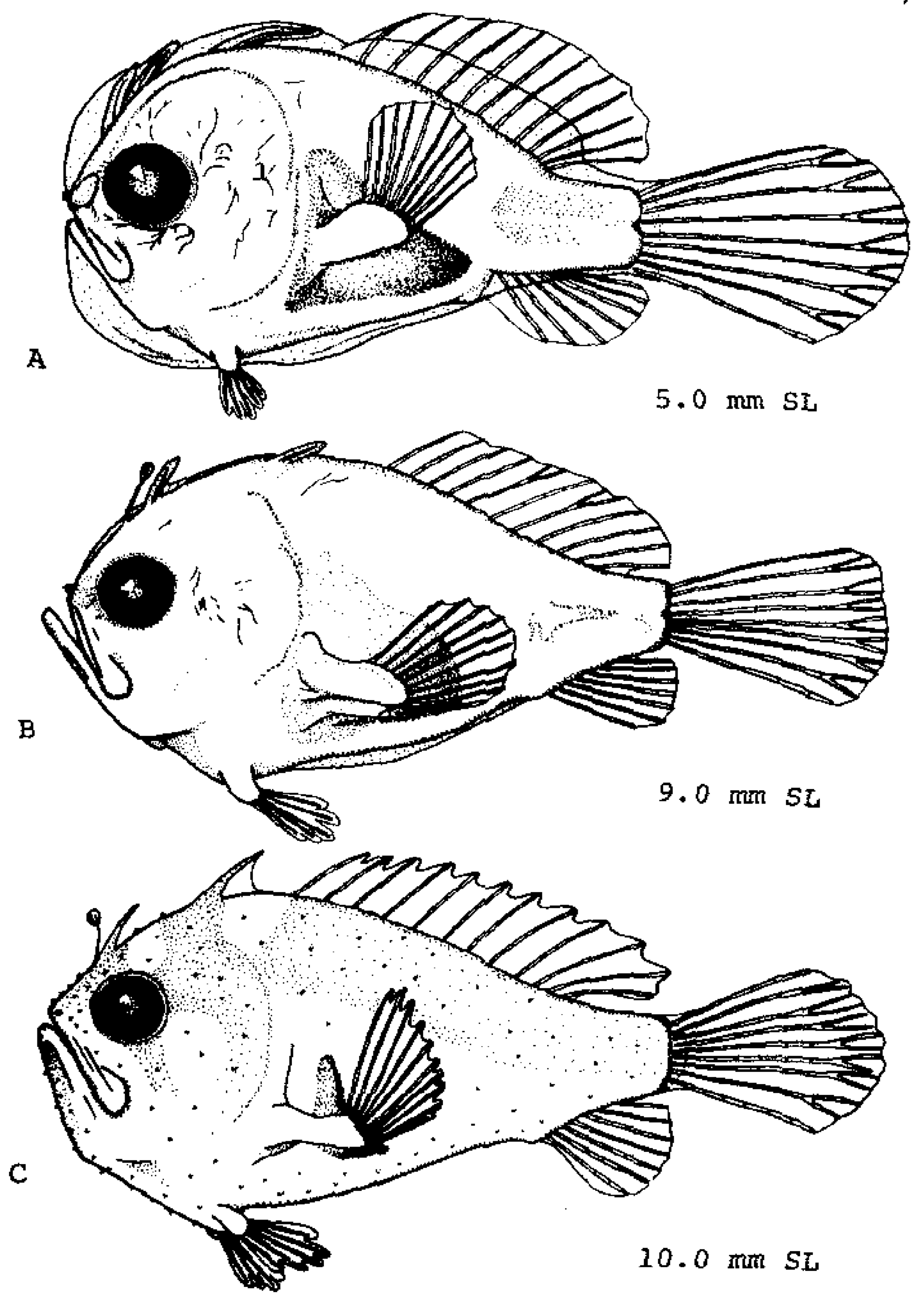

Fig. 197. *Histrio histrio*, Sargassumfish. A. Prejuvenile, 5.0 mm SL. B. Prejuvenile, 9.0 mm SL. C. Prejuvenile, 10.0 mm SL. (*A-C, Adams, J. A., 1960: fig. 2.*)

settled down over the tip of the third spine as figured for 9.0 mm SL; at 9.0 mm SL the illicium differentiated; a few soft dorsal rays branched; at 10.0 mm SL dorsal spines fully defined; indentation beginning in the membrane between tips of soft dorsal and caudal rays; anal rays still figured as unbranched at 9.0 and 10.0 mm SL; pectoral rays beginning to overgrow their membrane at 10.0 mm SL; pelvic bases have elongated at 9.0 mm SL and the envelope over the fleshy bases of pectoral and pelvic fins has consolidated with the main body outline. Separation of the envelope from the body proper persists only around the bases of the dorsal spines and in the loose skin under the belly; at 10.0 mm SL the integument everywhere closely applied to the body,[5] although still shown as loose ventrally at ca. 15.2 mm SL in a specimen of undetermined origin,[10] this figure in most respects comparable to specimens 9–10 mm SL (GED). Minute tags which will become dermal cirri appear at 10 mm SL. Head and its parts proportionally larger at 10.0 mm SL than at 9.0 mm SL.[5]

Pigmentation: The midgut pigmentation is reduced in the 5.0 mm SL specimen and the chromatophore pattern on the head is extensive. At 9.0 mm SL midgut pigmentation is much faded, but still covers a wide area; at 10.0 mm SL this has shrunk to a small patch.[5]

JUVENILES

Specimens described 15.5–28 mm SL.

D. III, 11–12; A. 7; C. 9; P. 10–11; V. 5.[5,9]

As a proportion of SL at 15.5–19.0 mm SL: Mean head length 0.413 (0.376–0.452); mean pre-soft dorsal length 0.550 (0.529–0.568); mean preanal length 0.695 (0.647–0.755); mean prepelvic length 0.375 (0.316–0.432).[5] At 28 mm SL: Head 0.63 SL; its length 2.4 times its width and 1.2 times longer than its depth; snout 0.9 eye; eye 0.17 head; interorbital 0.55 eye, 0.09 head; filament of first dorsal spine 0.15 head length; second and third spines 0.28 head length.[9]

At 15.5 mm last two dorsal and all anal rays shown as branched, and indentation of the membrane between

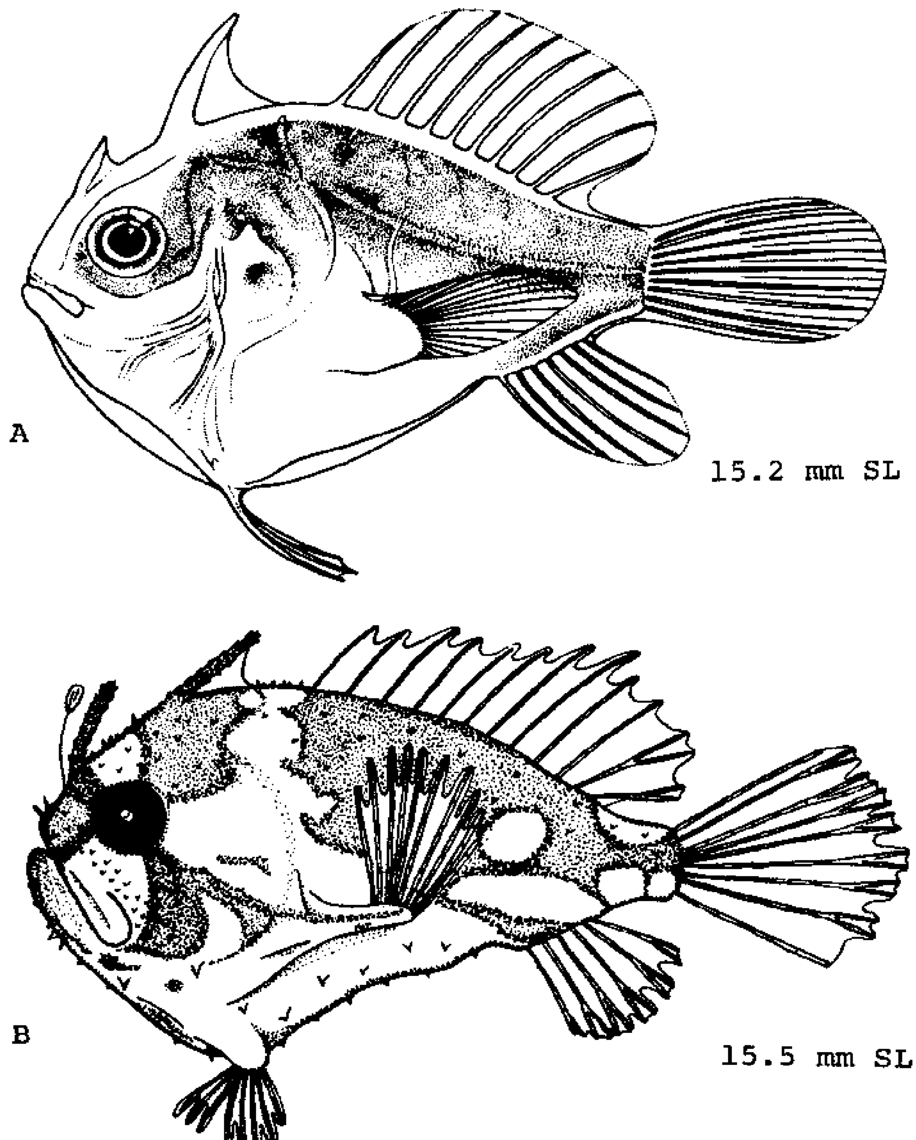

Fig. 198. *Histrio histrio*, Sargassumfish. A. Prejuvenile, 15.2 mm SL. B. Juvenile, 15.5 mm SL. (*A, Fowler, H. W., 1928: fig. 81. B, Adams, J. A., 1960: fig. 3.*)

tips of caudal and anal rays is well developed, lending a ragged appearance to all the fins. Dermal cirri are more profuse, elongating, particularly on the dorsal spines.[5] At 28 mm SL snout described as short and obtuse; the teeth as small, conical, recurved and depressible, in bands on jaws, vomer and palatines; the caudal fin as rounded; and the pelvic fins as jugular in position. Dermal cirri were not figured.[9]

Pigmentation: At 15.5 mm SL the mottled markings of the usual adult color pattern have developed, and the midgut pigmentation characteristic of earlier stages is barely discernible.[5] At 28 mm SL coloration is similar to that of the adult.[9]

GROWTH

From ca. 2.0 to ca. 6.0 mm SL a period of axial elongation predominates. From ca. 6.0 to ca. 12 mm SL compensating allometry is exhibited. By 15 mm SL growth is becoming relatively isometric.[5] The length-frequency histogram for Florida in 1966–1967 [26] suggests that growth from 5 to 45 mm SL took four to five months (GED).

AGE AND SIZE AT MATURITY

No information.

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Phrynelox scaber (Cuvier), Splitlure frogfish

ADULTS

D. III–11–13 (mode 12) last 2 or 3 branched; A. 7–8 (mode 7) all branched; P. 10–11 (mode 11) none branched;[4,10] V. 5, only the last branched;[10] C. 9;[6] vertebrae 18[14]–19,[13] 10 precaudal and 8 caudal.[14]

As a proportion of head length (to gill opening): Snout .17–.23, eye .066–.095; interorbital .16–.23, maxillary .36–.38, head width .71. As a proportion of SL: head length .61; head width .33–.36; illicium .23, second dorsal spine .13, third dorsal spine .19; soft dorsal height (at fifth ray) .20; anal depth (at third ray) .21; anal base .15; caudal length .24; pectoral length .27; caudal peduncle length .13[1,5] caudal peduncle depth .19.[10]

Head large, deep, anterior profile evenly convex when mouth closed; mouth long, nearly vertical; upper lip thin, tough; lower lip thicker, also tough; mandible broad, with a slight symphyseal knob in front. Jaw teeth cardiform in narrow bands, individually small, slender, conic and sharp; palatine teeth similar to jaw teeth, in two patches, median line of mouth roof without teeth; two small sets of pharyngeal teeth above and two below. Tongue large, broad, depressed, smooth, free in front and along sides, convex in front.[1] First gill arch with filaments on anterior portion[2] of ventral half only.[8] Gill opening a small slit immediately below pectoral base.[1] Vent near anal fin origin, conspicuous. Body laterally compressed, deepest at dorsal origin.[1] Skin roughened everywhere with spinous dermal ossicles, many of these bifid or trifid.[1,3] Cirri also abundant on sides, longer dorsally, filamentous and branching ventrally; these cirri much more pronounced in males than in females.[9,11] Lateral line obscure, only evident anteriorly.[1] Reported to inflate with air or water if handled.[5] An air bladder present (TWP). Paired fins freely mobile, with great clasping power, enabling the fish to cling to substrates;[6] pectoral base elbowed and arm-like, supported by 3 radials;[13] tips of pectoral rays projecting slightly beyond membrane;[1] pelvics similar, but much smaller,[10] jugular in position, last ray divided;[8] first dorsal spine modified into an illicium or "bait" used in luring prey;[7] base of illicium advanced beyond margin of lower jaw; rod of illicium same length as or slightly longer than unmodified second dorsal spine; tip of illicium (esca) bifid with halves fleshy, worm-like, each with a few short attached filaments,[1,2,5,10] in use the halves spread and trailing as the rod moves forward and backward, when not in use the halves of the esca rolled and folded back into a hollow behind second spine.[7] Second and third dorsal spines fleshy, not connected by membrane, with projecting cirri that are likewise longer and more abundant in males than in females;[9] soft dorsal long, high, its rays unevenly spaced; with close-set cirri along its basal margin;[1,5] caudal fin large, rounded, with median rays longest; anal fin small, set far back, ending slightly farther back than dorsal.

Pigmentation: Two primary color phases, the rarer one black except for a whitish lure on illicium (dark phase originally described as *Antennarius nuttingi*).[10] More commonly light to medium gray, brown or reddish with irregular black spots and short bands on body, head and fins; bands in two radiating systems, a major system centering about eye, a minor system centered about base of third dorsal spine; rounded, non-ocellated black spots in several transverse series on fins and body; iris with radiating striae; upper surface of tongue from base to tip mottled with drab in a distinct pattern on a white ground.[1,5,10]

Maximum length: 150 mm.[10]

DISTRIBUTION AND ECOLOGY

Range: Atlantic coast of the Americas from New Jersey[1] through Texas[12] and south to Rio de Janeiro;[6] Bermuda,[3] the Bahamas,[2] West Indies[10] and the Guinea coast of West Africa.[9]

Area records: Corson's Inlet, Cape May County, New Jersey.[1]

Habitat and movements: Adults—seined in Bermuda on grassy bottoms where there are scattered broken bits of coral, dead conch shells and other similar objects. Walk on fins as do *Antennarius* species, but can swim short distances at great speed, using tail, with other fins floded back against body.[3] Different habitats including mud bottoms.[10] In Bahamas near a piling,[11] and from water less than 0.6 m deep.[2] In Tortugas, Florida, from 18–22 m depth.[5]

Larvae—yolk-sac larvae float upside down at surface; in aquaria after yolk sac absorbed larvae remain within 25 mm of the surface until they die (LAK).

Prejuveniles and juveniles—no information.

SPAWNING

Location: Spawning occurs at the surface after a courtship similar to that of *Histrio histrio* (LAK).

Notes: No reports of spawning seen in field. Have spawned in aquaria,[3,11] but few details are published.

Season: Late April, Bahamas[11] (only report).

Time: Daytime.[13]

Temperature: 27 C (20 minutes after spawning).[11]

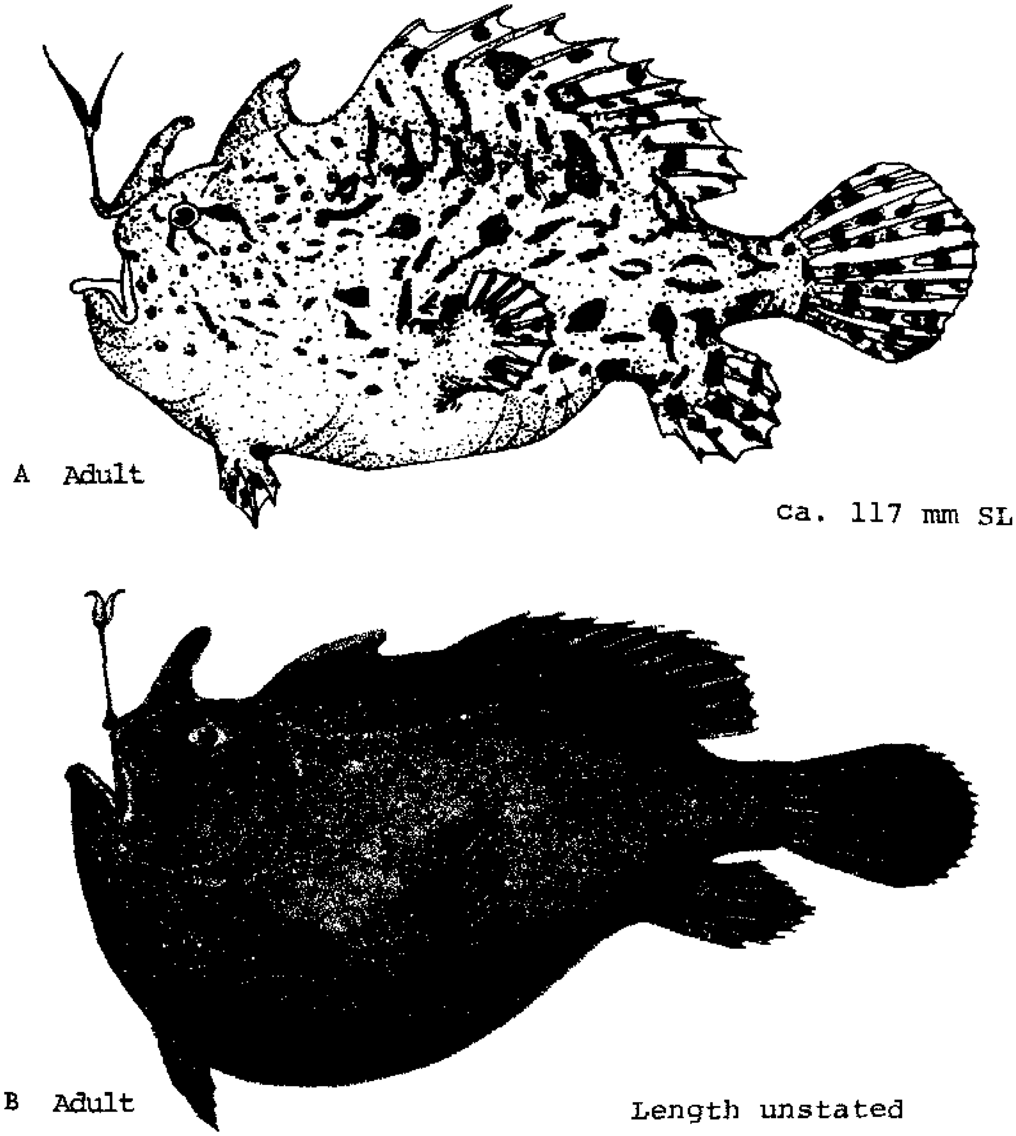

Fig. 199. *Phrynelox scaber*, Splitlure frogfish. A. Adult, ca. 117 mm SL, typical color phase. B. Adult, length unstated (*nuttingi* form, melanistic coloration, probably female). (*A, Barbour, T., 1942: Pl. 8. B, Garman, S., 1896: pl. 2.*)

Fecundity: Ca. 125,000 eggs in a raft (LAK).

EGGS

Location: Eggs embedded in a raft of gelatinous material. Usually one, sometimes two eggs each in chambers divided by clear, resilient sheets, each chamber rendered polyhedral by pressure from adjacent chambers. Envelope of the raft composed of a second type of gelatinous substance having microscopic surface striations and also with pores opening to the outside water. Rafts up to 900 mm length and 120–150 mm width mentioned, without definite species identification.[11] Scroll of eggs smaller than diameter of a lead pencil when ejected, expanding, as soon as free in the water, to a raft 75–100 mm in length, which floats.[3]

Ovarian eggs: Embedded in a mucous scroll ca. 80 mm in length, closely rolled toward the center from opposite ends.[6]

Fertilized eggs: Slightly oval, major axis 0.70 mm, minor axis 0.65; color light yellowish and perfectly clear, without oil droplets or granules of any kind.[11]

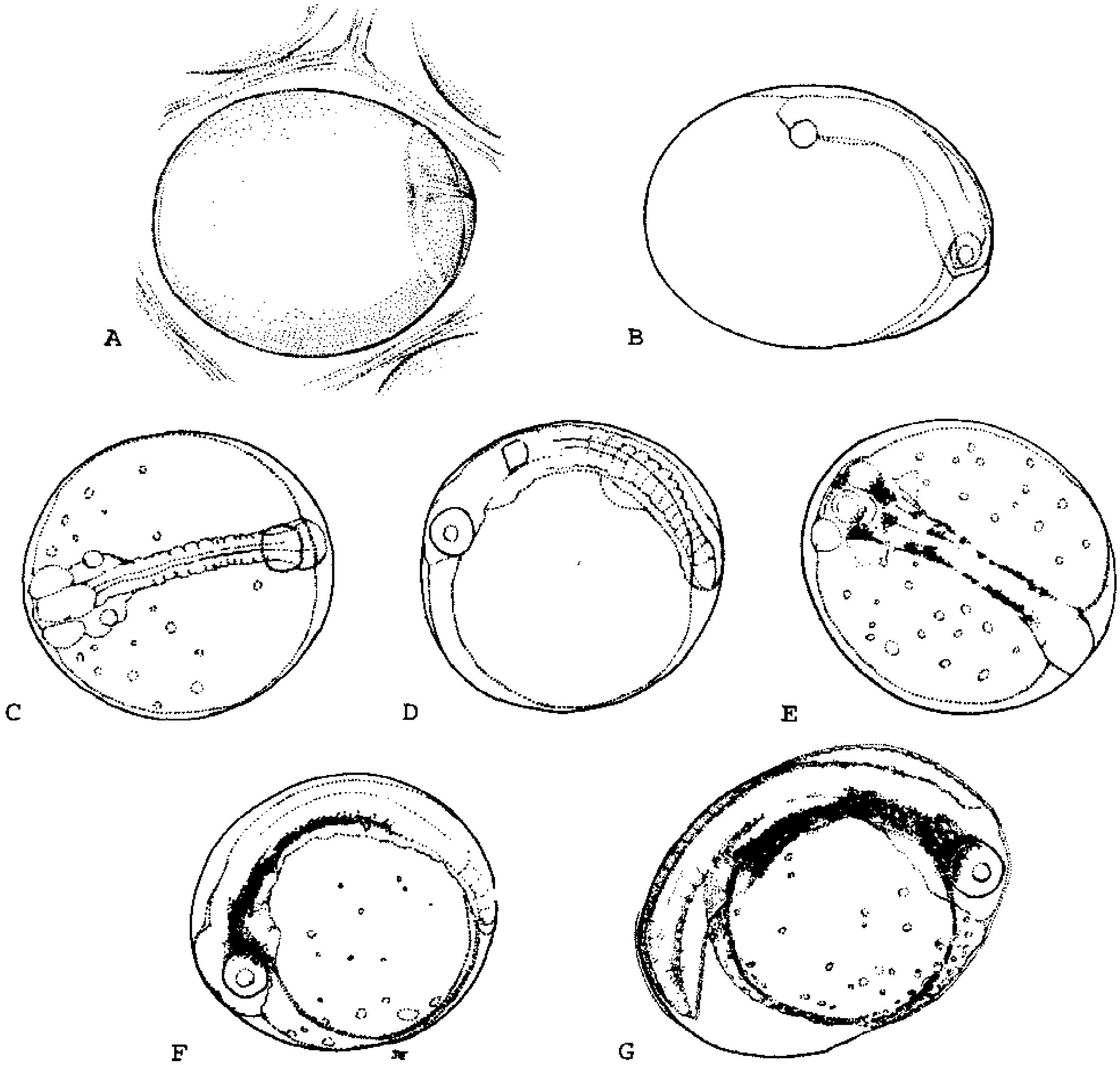

Fig. 200. *Phrynelox scaber,* Splitlure frogfish. A. Egg, 2-cell stage. B. Embryo, at lens formation, Kupffer's vesicle present. C. Embryo, showing auditory placodes. D. Embryo, pectoral buds forming. E. Embryo, first stage showing pigment, yolk surface vacuolated. F. Late embryo. G. Embryo, just before hatching. (*A-G, Rasquin, P., 1958: pl. 53, fig. 4; pl. 58, figs. 1, 4; pl. 59, fig. 4; pl. 60, figs. 1, 3, 4, delineated by Joan Ellis.*)

EGG DEVELOPMENT

Report based on aquarium-spawned pair, numbered steps follow Rasquin.[11]

1—fertilized ovum; no indication of differentiation into animal and vegetal poles.
2—two cells; time not given.
3—four cells; second cleavage began 20 minutes after fertilization, duration of stage 20–25 minutes.
4—eight cells; duration of stage 20–25 minutes.
5—16 cells; duration of stage 20–25 minutes.
6—32 cells; duration of stage about one hour.
7—64 cells; no segmentation cavity, no further times given before hatching.
8—early blastula; segmentation cavity developing, junction zone of outer cells and yolk poorly defined.
9—late blastula, definition of junction zone developing.
10—early gastrula; germ ring widens posteriorly, defining anterior-posterior axis.
11—middle gastrula; marginal periblast, neural crest and a narrow perivitelline space forming, caudal end of the neural keel slightly overhangs marginal periblast.
12—late gastrula; anterior neural keel advancing rapidly.
13—optic vesicles form; some differentiation of trunk mesoderm.
14—tubulation; definitive notochord formation; Kupffer's vesicle formation; melanin granules form in cells ventrolateral to the neural tube, as revealed in fixed and stained embryos, not visible in living embryos until next stage; optic vesicles invaginate.
15—appearance of somites; blastopore still open; embryos tend to rotate until yolk uppermost; three primitive divisions of brain evident; optic cup invagination; gut differentiates into pharyngeal and midgut regions; heart anlage appears; gill slits begin forming but do not open. Two rows of melanophores appear beside the notochord, a few on the head, and the posteriormost migrate ventrally beneath the gut.
16—blastopore closes; five brain divisions evident and cranial nerves forming; pectoral limb buds forming; heart formed, open at both ends, no sign of blood vessels; gill slits broken through; lenses differentiated. Choroid layer of eye darkening with melanin granules but no melanophores; melanophores plentiful at anterior end of gut, two wing-like aggregations of pigment extend outward at the sides and approach the choroid coat of the eye, dorsally resembling a black letter Y that ends abruptly a short distance anterior to the anus, tail free of any pigment.
17—just before and at hatching; time less than 75 hours post-fertilization at 21–27 C; retinal pigmentation still much lighter than that surrounding the gut; yolk volume considerable with prominent vacuolations around yolk periphery; third and fourth ventricles of brain prominent and extensive; vacuolations evident in outside ectoderm that will form the bubble; heart still open at both ends, the only possible circulation being within the subdermal space around the heart; Kupffer's vesicle disappears; there is no evidence during this or following yolk-sac larval period of swim bladder anlage; gut complete; pronephric ducts present; liver developing; fin bud changes orientation to stand out from yolk surface but still consists of undifferentiated cells; tail free from yolk sac and vigorously lashed; the raft beginning to disintegrate rapidly.[11]

YOLK-SAC LARVAE

Hatching length ca. 0.90–0.98 (from measured photographs). Size at end of stage not described. Duration of stage 4–5 days at 21–27 C.[11]

Numbered stages below follow Rasquin[11] (temperature 21–27 C):

18—3–4 days post-fertilization; yolk at hatching nearly spherical, ca. 0.42 mm diameter; subdermal space or "bubble" greatly enlarged over previous stage, its exterior covered with a pattern of large vacuolated and granular cells; pectoral fins pushed out at an angle of about 60° with sides; anus open.
19—4–5 days post-fertilization; gut has a pronounced sigmoid curve; gills, urinary bladder and rectus muscles of the eye forming; gill clefts opening during the stage.
20—yolk sac reduced considerably and prominently vacuolated; lens and cornea visible; eyes rotating forward to give biocular vision; mouth not yet open; heart still open at both ends; peritoneum and various cartilaginous structures forming.
21—mouth open; pectorals large and used extensively in swimming; vacuolated cells of outside ectoderm over head and heart regions enlarged and appearing hypertrophied; dorsal aorta forming but not connected to heart; heart two-chambered; yolk remnant broken into large flakes.
22—yolk remnant being enclosed in liver; additional rotation of eyes, their anterior surfaces appearing slightly flattened; heart still open; gas developing in posterior gut (suggested to represent malfunction and presage death of aquarium larvae).[11]

Stage ending about 190 hours (8 days) after fertilization.[11]

Pigmentation: The only obvious change between stages 17 and 18 is darkening of choroid and retinal eye pigmentation. A few melanophores have migrated between the notochord and the neural tube in the anterior region. Eye pigmentation complete by stage 22. The distinctive "Y" pattern of pigment has become diffuse by stage 19

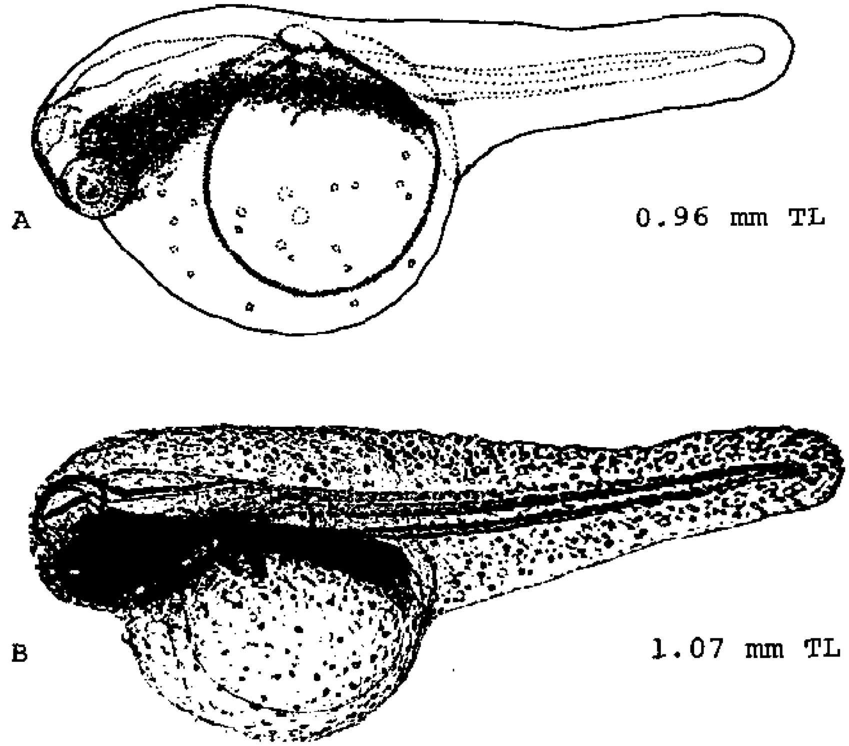

Fig. 201. *Phrynelox scaber*, Splitlure frogfish. A. Yolk-sac larva, 0.96 mm TL, 100 hours post-fertilization. B. Yolk-sac larva, 1.07 mm TL, 77 hours post-fertilization. (*A, B, Rasquin, P., 1958: pl. 61, figs. 1, 2; A, delineated by Joan Ellis.*)

and the larvae increasingly difficult to distinguish from similar stages of *Histrio histrio*.[11]

LARVAE

Three days of survival by moribund aquarium-hatched larvae are described.[13] Sizes not given. Temperature 21–27 C.

23—otoliths forming; heart divided into four chambers, aortal connections formed; skin over subdermal space differentiated histologically into four layers, the outer with small, blunt processes extending outward; jaw musculature developed.
24—no further development of organs, mortality heavy.
25—tenth day post-fertilization, no further development, mortality complete.[13]

Pigmentation: Visceral organs heavily invested with melanin, this clumped in a way characteristic of the moribund condition before death.[11]

JUVENILES

No information.

GROWTH

No information.

AGE AND SIZE AT MATURITY

No information.

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Chaunax stigmaeus

Chaunacidae

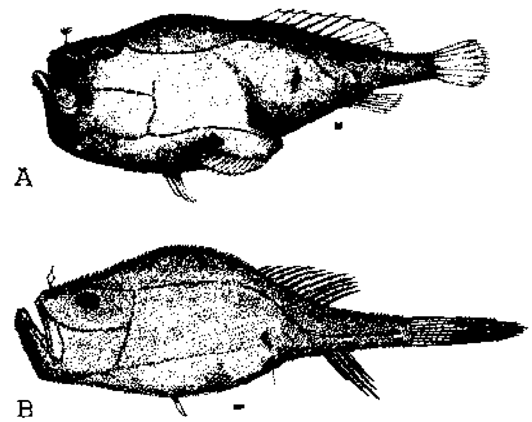

Fig. 202. A. *Chaunax nuttingi* Garman, length unstated. B. *Chaunax pictus* Lowe, ca. 27 mm SL. (*A, Garman, S., 1896: Pl. 3 fig. 2. B, Goode, G. B., and T. H. Bean, 1895: fig. 398.*)

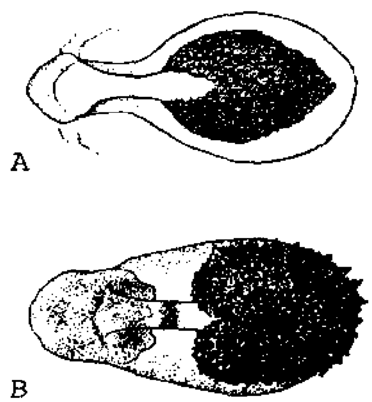

Fig. 203. Illicia (depressed into niche) of: A. *Chaunax pictus* Lowe. B. *Chaunax stigmaeus* Fowler. (*A, B, Fowler, H. W., 1946: figs. 4, 5.*)

FAMILY CHAUNACIDAE

This family, allied to the Antennariidae, consists of a single genus, *Chaunax*. Adult chaunacids have a characteristic loose skin, which in the region over the head and eyes is similar to the prejuvenile "bubble" (Adams, 1960) of other lophiiforms. They also possess five dorsal spines, rather than three or four as do antennariids, but the posterior four remain hidden beneath the loose skin and are revealed only by dissection (Longley and Hildebrand, 1941). Other characteristic features include a nearly vertical mouth, giving the anterior profile of the head a truncate appearance, reduced pelvic fins with only four rays in the species described, gill openings above and behind the pectoral fin axils, and unique skeletal features described by Regan (1912). The family occurs world-wide and is usually collected offshore and from the bottom at moderate to considerable depths.

Systematics in the group needs revision (TWP); species cannot now be delimited with confidence. The following account uses the name *Chaunax stigmaeus* Fowler (1946) from a specimen at 146 meters depth off the coast of New Jersey, which might be a synonym of the older *C. nuttingi* Garman (1896) from a depth of 290 meters near Sand Key, Florida. Besides the type specimen two earlier specimens discussed by Nichols and Firth (1936) from 100 to 110 meters in Virginia waters are included. The three specimens share the following: 13 or 14 pectoral fin rays, 11 or 12 soft dorsal fin rays, at least eight caudal rays, and an esca which is black anterodorsally, white posterodorsally, broad, and reaches the posterior edge of the niche behind it when depressed. The esca of *C. nuttingi* was described and figured as bilobed, and the type had at least one more soft dorsal ray. The illicial rod of *C. stigmaeus* is hinged behind the anterior edge of the niche into which it folds, while that of *C. pictus* Lowe, the common species in deeper water, was figured by Fowler (1946) as hinged at the anterior end of the niche. Pectoral fin ray counts of 11 characterize *C. pictus* (Goode and Bean, 1895) and all the specimens examined by Longley and Hildebrand (1941); pectoral counts as low as nine were observed in additional specimens examined while preparing this account.

Chaunax stigmaeus Fowler, Broadhanded gaper

ADULTS

D. I–11 [8]–12; [1] A. 5 [8] (6 or 7 if minute anterior rays present, GED)–7; [1] C. 8 [1]–11 *(from drawing);* [8] P. 13–14; V. 4; [1,8] vertebrae 19; [4] gills 2 1/2.[1]

Proportions as percent standard length: Head 57 [8]–62; eye 8.4 [1]–9.1; [8] snout 9.8–12.8; interorbital 13.1 [1]–16.4; [8] maxillary 17.9–19.4 [1] (N=1,[8] 2 [1]).

Trunk somewhat compressed posteriorly, depressed anteriorly; head broad, depressed; snout short, broad, truncate; [2] mouth wide, almost vertical; [3] maxillary widened and rounded at its outer end; jaw teeth small, slender, in villiform bands [2] of about 4 irregular series, many of inner or larger ones more or less depressible; 4 continuous villiform bands of teeth on palate; [8] pharyngeals also dentigerous; no gills on first gill arch or dorsal half of fourth; branchiostegals lacking; gill opening small,[3] its length about half of eye diameter,[8] located behind origin of soft dorsal fin and well dorsal to pectoral fin base.[4,8] Skin over eyes scaleless but continuous with skin of head; [5] body and head skin loose, soft, forming folds, especially loose on lower surface of body; scales in the form of minute spinules, giving a velvety texture to the skin; canals of the lateralis system prominent.[8] First dorsal spine modified into an illicium bearing a fleshy, expanded esca with a fringed margin which folds backward into a pit or niche behind it, hinge of illicium located behind anterior margin of pit (in contrast to *C. pictus*) about one-fourth of distance from anterior to posterior margin of the pit; [8] four additional dorsal spines hidden beneath loose skin of head in a related form [5] and probably in this one (GED), the first two long, the other two vestigial [5] (none of these included in external counts, GED); soft dorsal origin near midpoint of SL; caudal fin *rounded; anal fin small; pelvic fins almost vestigial,* retracted into pits in the skin; pectoral fins short, broad and rounded.[8]

Pigmentation: Esca gray-black anterodorsally and bril-

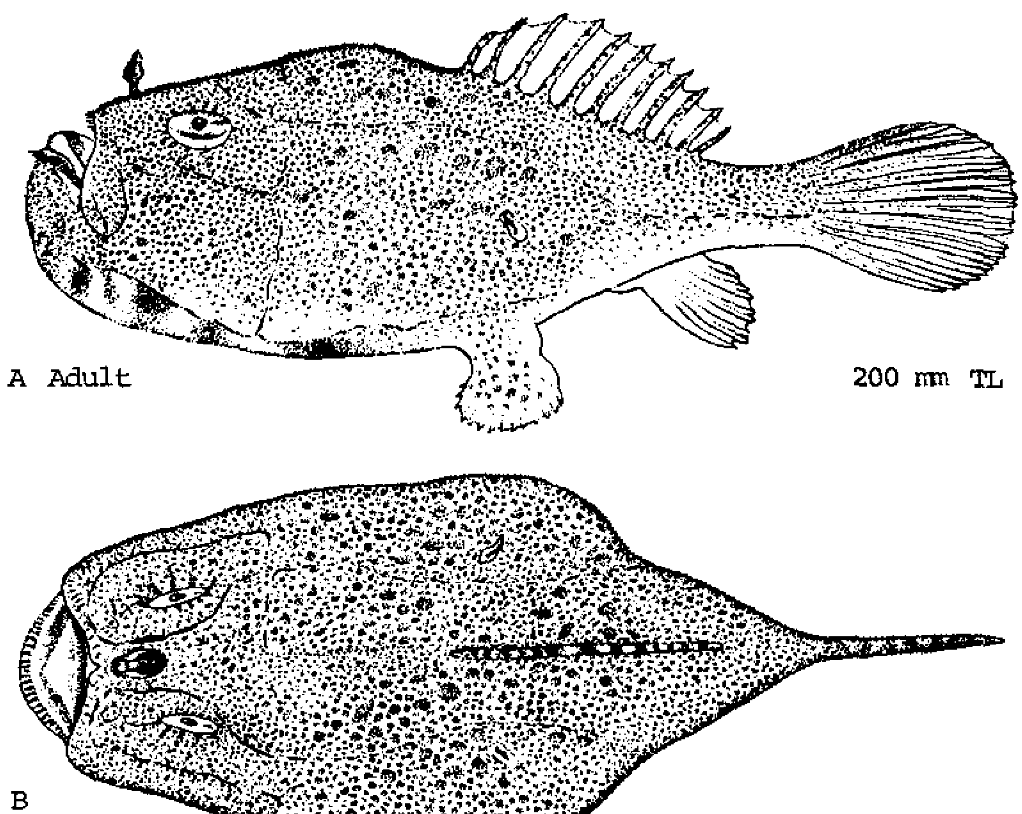

Fig. 204. Chaunax stigmaeus, Broadhanded gaper. A. Adult, 200 mm TL, lateral view. B. Lateral view of same. (A-B, Fowler, H. W., 1946: figs. 2, 1.)

liant white posteroventrally,[1,8] illicial stalk rose with two darker rings;[8] when fresh in alcohol upper surfaces dull olivaceous brown with numerous small dark olive markings, these extending on dorsal, caudal and pectoral fin rays; fin membranes and sides with various shades of red; lower surface brighter red to orange, four rose red blotches along lower side of head; an indistinct transverse rose red bar on under side of each pectoral fin; anal fin red; iris deep rose red.[8]

DISTRIBUTION AND ECOLOGY

Range: Uncertain until specific status established, the three specimens described from one occurrence 129 km southeast of Atlantic City, New Jersey[8] and two an unspecified distance southeast by south from Chesapeake lightship in Virginia waters;[1] *C. nuttingi* Garman from the Bahamas similar in pectoral fin ray counts, but differing in details of the illicium; specimens examined by Longley and Hildebrand from the Florida Keys northward to Rhode Island, considered by Hildebrand[5] to be indistinguishable from *C. nuttingi* and from *C. pictus*, but having only 11 pectoral fin rays.

Area distribution: Uncertain (see Range), possibly throughout (GED).

Habitat and movements: Adults or juveniles—unknown except for depth of three specimens described, 146 m[8] and 100–110 m[1] (presumably trawled from bottom, GED); adults of this family seem to live close to the bottom[6] in waters normally 238–783 m deep.[7]

Larvae and prejuveniles—young of this family often caught bathypelagically,[6] no other information.

SPAWNING

No direct information, ovaries scrolled as in antennariids, suggesting production of epipelagic rafts, although neither eggs nor rafts have been reported.[6]

EGGS

No information.

EGG DEVELOPMENT

No information.

LARVAE

No information.

JUVENILES

No information.

GROWTH, AGE AND SIZE AT MATURITY

No information.

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Ogcocephalus vespertilio

batfishes
Ogcocephalidae

FAMILY OGCOCEPHALIDAE

At the time of this writing, the family Ogcocephalidae contains about 50 valid named species and at least nine undescribed species distributed among nine genera (Bradbury, 1967; Böhlke and Chaplin, 1968). Distribution of the family is world-wide in tropical and temperate latitudes, although the eastern Atlantic has only one species and over half the species are Indo-Pacific. The western Atlantic has about 14 species, including several undescribed ones, which may include some or all of the specimens described below as *Ogcocephalus vespertilio* (Linnaeus). Systematic difficulties with the forms covered by the common name longnose batfish were indicated by Longley and Hildebrand (1941).

Unlike frogfishes of the family Antennariidae and the other families of the order, batfishes have the spinous dorsal fin represented by only a single spine, the first. Like most other members of the order Lophiiformes, the first spine is modified into a moveable lure used to attract prey within striking distance. In batfishes the lure (illicium) can be retracted into a tube or channel located beneath an overhanging bony rostral shelf and enclosed at the sides by projections of the frontal bones. Retraction is accomplished by sliding of the pterygiophore on which the illicial bone (the modified spine) is supported. The fleshy lobe (esca), which is carried at the tip of the illicial rod (bone) in other pediculate families and actually serves as the "bait," almost completely envelops the illicial bone in this family. Details of the structure and the terms used here to describe it were given by Bradbury (1967) and illustrations of its deployment in fishing for prey can be found in Breder (1949).

Other characteristics of the family include well developed scales in all species, pelvic fins present in all species although reduced in some, gill rakers present in all species, no species have gills on the first arch, and most species are depressed and flattened ventrally (Bradbury, 1967).

Ogcocephalus vespertilo (Linnaeus), Longnose batfish

ADULTS

D. 4; A. 4;[2,3,4,7,8,9] C. 9;[2] P. 11[2,7,8]–12;[8,9] V. 5;[2,10] vertebrae 19;[6] gills 2 1/2;[1,10] branchiostegals 5;[3,4] no pseudobranchiae;[3,6] pectoral fin radials 2.[6]

Proportions as percent SL: Head 42.0–45.0; eye 5.8–9.0; rostrum 11–15 (N=5);[7] snout 14.[9] As percent SL without rostral process: head 47.6[9]–50;[8] greatest depth 22;[8,9] eye 6.0[9]–6.8;[8] interorbital 6.0–7.4;[8] rostral process 21.7;[8] (N=2,[8] 1[9]).

Body ovate, depressed anteriorly;[2] disc triangular,[1] *i.e.*, pectoral fins attached to shoulder-like lateral expansions;[2] caudal trunk relatively small and slender,[4] tapering posteriorly;[2] head depressed, but cranium well elevated above the general surface of disc; a pointed rostral shelf,[1] or process;[8] rostral groove longer than broad;[3] iris of eye specialized with lobes, termed pupillary opercula, giving the pupil an irregular shape;[1] mouth small,[1,3] horizontal;[6] jaws downwardly protractile; maxillary extending behind pupil of eye.[4] Jaw teeth in villiform bands; bands of teeth also present on tongue, palatines and vomer,[1,4] gill rakers in the form of oval plates covered with small teeth, present on all four arches;[1] gill opening very small,[3,4] about diameter of pupil,[4] located posterodorsal to axil of pectoral fin.[3] Scales modified into bucklers, multi-spined structures with spines and protuberances arranged in a radiating pattern. Lateral line complete, extending in an unbroken series from postorbital region back over the disc, curving downward behind gill opening and following flank posteriorly out onto caudal fin. Pedicels of pectoral fins arm-like, well separated from the body wall;[1] pelvic fins long, directed horizontally outward and backward, extending beyond origin of soft dorsal fin;[4] first dorsal spine reduced to a small bone termed the illicial bone (a term applicable to this spine in all members of the order Lophiiformes), enclosed in ogcocephalids within three fleshy lobes of a lure, termed the esca, which can be protruded or withdrawn into an illicial tube or cavity

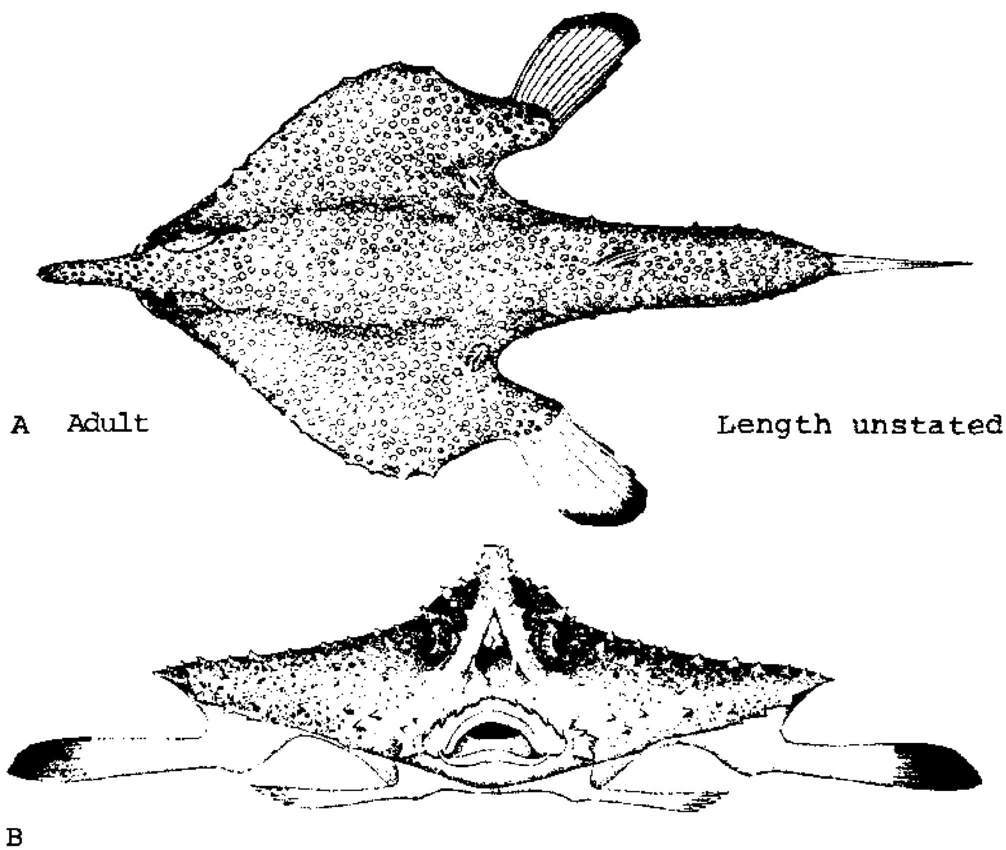

Fig. 205. *Ogcocephalus vespertilio*, Longnose batfish. A. Putative adult, length unstated, dorsal view. B. Ventral view of same individual. (*A, B, Jordan, D. S., and B. W. Evermann, 1896–1900: pl. 192, figs. 958, 958b.*)

by sliding of the supporting pterygiophore; pterygiophore with a detached bridge element anteriorly; illicial tube scaleless, recessed under the overhanging rostral shelf, shielded laterally by modified processes of the frontal bones; other dorsal spines absent; [1] soft dorsal fin origin nearer to gill openings than to base of caudal fin; [4] anal fin very small, its origin well behind that of the soft dorsal fin; [7,10] edge of caudal fin even, slightly convex.[13] Lacking an air bladder.[10] Third through sixth vertebrae elongate.[6]

Pigmentation: In life hazel above; tips of larger spines along back before dorsal rosy, the many lesser spines everywhere gray-tipped; a fine pattern of spots in radiating series about gill openings; iris with fine lines radially arranged at pupillary border forming a peripheral network; pectoral and caudal fins buff-yellow over basal half, passing through maroon-purple to prune-purple at tips, the contrast between the yellow basal two-thirds and the darker outer third being sharper on under side of pectorals; belly, maxillary membranes and buccal cavity coppery red; [8] also described as grayish brown [2,4,10] or dusky gray [7] above; with black spots; [4] pale reddish [2,7,10] or coppery [4] below; dorsal fin plain; anal fin with dusky margin; caudal and pectoral fins white with a broad black margin; pelvic fins white.[4] In preservation dark brown above with pale spines making the surface appear pale-spotted and dotted; pectoral and caudal fins dusky in a specimen 81 mm (SL?) black in a specimen 126 mm (SL?).[8]

Maximum size: To 305 mm TL.[4,10]

DISTRIBUTION AND ECOLOGY

Range: New York [5] or Cape Cod [3] to Texas,[9,13] Venezuela [7] and possibly same species to Brazil (type locality of nominal *vespertilio*); [8] recorded from the Bahamas.[16]

Area distribution: Rare in the southern part of Chesapeake Bay.[2]

Habitat and movements: Adults and juveniles—mud and sand bottoms in the marine environment at depths of 20 [8] to 181 m.[3]

Larvae and prejuveniles—no published information; presumed to be epipelagic (GED) as unspecified members of the family are reported to be,[14] and as a single specimen 17.5 mm TL of *Ogcocephalus* sp. has been taken with plankton nets.[15]

SPAWNING

No direct information; [11] ovaries scrolled, probable that an egg raft is produced.[12]

EGGS

No information.

EGG DEVELOPMENT

No information.

LARVAE

No information.

JUVENILES

No information.

GROWTH

No information.

AGE AND SIZE AT MATURITY

A female 253 mm TL appeared to be of adult size, although ovary lacked ripe or resorbing ova; acellular material in ovarian lumen might have represented mucoid remnants from a spawning.[12]

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